

**UNITED STATES DEPARTMENT OF AGRICULTURE**  
**BUREAU OF CHEMISTRY AND SOILS**  
In Cooperation with the Iowa Agricultural Experiment Station

---

**SOIL SURVEY**  
**OF**  
**WARREN COUNTY, IOWA**

BY

**A. M. O'NEAL, Iowa Agricultural Experiment Station, in Charge,**  
**and R. E. DEVEREUX, U. S. Department of Agriculture**

Beginning with the 1923 Series, Soil Survey Reports will be issued separately. These reports of the individual areas will be sent to libraries as soon as they are available and should be filed, preserved, and ultimately bound to take the place of the bound volumes of the Field Operations which have previously been supplied by the department. The reports for each year will be consecutively numbered, the last report for a particular year bearing the conspicuous notice: "This number is the final and last Soil Survey Report for the Year 192-."



# BUREAU OF CHEMISTRY AND SOILS

HENRY G. KNIGHT, *Chief*  
A. G. McCALL, *Chief, Soil Investigations*  
SYDNEY FRISSELL, *Editor in Chief*

## SOIL SURVEY

CURTIS F. MARBUT, *in Charge*  
T. D. RICE, *Inspector, District 3*

## COOPERATION

### IOWA AGRICULTURAL EXPERIMENT STATION

C. F. CURTISS, *Director*  
W. H. STEVENSON, *In Charge Soil Survey*  
P. E. BROWN, *Associate in Charge*

## CONTENTS

	Page
County surveyed.....	1
Climate.....	3
Agriculture.....	4
Soils.....	11
Tama silt loam.....	14
Grundy silt loam.....	17
Muscatine silt loam.....	18
Clinton silt loam.....	20
Carrington silt loam.....	21
Carrington loam.....	22
Carrington fine sand.....	23
Shelby loam.....	23
Shelby silt loam.....	25
Lindley silt loam.....	25
Waukesha silt loam.....	26
Waukesha loam.....	27
Bremer silt loam.....	27
Bremer silty clay loam.....	28
Bremer loam.....	29
Judson loam.....	29
Calhoun silt loam.....	30
Jackson silt loam.....	31
Wabash silt loam.....	31
Wabash silty clay loam.....	32
Wabash silty clay.....	33
Wabash loam.....	34
Genesee silt loam.....	34
Sarpy silt loam.....	35
Sarpy very fine sandy loam.....	35
Sarpy fine sandy loam.....	36
Summary.....	37

# SOIL SURVEY OF WARREN COUNTY, IOWA

By A. M. O'NEAL, Iowa Agricultural Experiment Station, in Charge, and R. E. DEVEREUX, U. S. Department of Agriculture

## COUNTY SURVEYED

Warren County is in the south-central part of Iowa, in the third tier of counties north of the Missouri State line. The northern boundary is 6 miles south of Des Moines. The county is square, measuring 24 miles in each direction. It contains 16 full townships, and has an area of 570 square miles or 364,800 acres.

Physiographically the county consists of a loess-covered drift plain that varies from undulating to strongly rolling. The greater part of the northern half is undulating or gently rolling. Here the hills are evenly rounded and the slopes are gentle and little furrowed by erosion, as in other parts of the county. The valley floors of the rivers and creeks are predominantly wider and the escarpments are less precipitous. South and east of a line drawn through Lida, Spring Hill, Indianola, Ackworth, and Hartford the relief is more pronounced. The inter-stream divides are less extensive than in the northern part of the county and they have a smoother surface and terminate rather abruptly on joining the rough eroded areas which border all the streams and drainage ways. Two exceptions to this general rule occur in the vicinity of Milo and Liberty Center, where level or gently undulating areas are extensive. Along the southeastern slopes of Middle River and South River the bluffs are more abrupt and the hills are higher than to the north and northwest where the bordering uplands have a gentler, less serrated appearance.

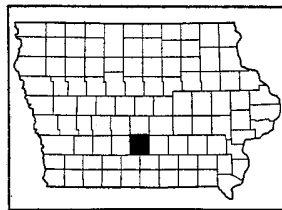


FIGURE 1.—Sketch map showing location of Warren County, Iowa

The alluvial deposits which occur along the rivers and practically all creeks of the area include the older materials which now occupy terrace positions and the more recent deposits that are subject to occasional inundation. The most extensive terraces are along Middle, South, and Des Moines Rivers, and small isolated areas occur along many of the larger creeks. The surface of these terraces is flat, except on the older more eroded terrace near Wick. The first bottoms or flood plains are wide. Along South, Middle, and Des Moines Rivers many of them are 1 mile or  $1\frac{1}{2}$  miles wide. They slope gently toward the streams, and a few areas are somewhat hilly.

The elevation of Warren County ranges from 760 to approximately 1,035 feet above sea level. Liberty Center, in the southeastern part of the county near the southern boundary, has an elevation of 1,030

feet; <sup>1</sup>Indianola, just north of the geographical center of the county, 966 feet; Lacona, near the southeast corner, 822 feet; Milo, in the east-central part, 972 feet; and Hartford, in the northeastern part, 880 feet. Carlisle, which is situated partly on the Des Moines River bottoms, has an elevation of 784 feet, and the altitude at the point where Des Moines River flows into Marion County is approximately 755 feet. The prevailing slope of the land is northeastward.

The drainage of the county is carried by Des Moines River, which forms about 6 miles of the extreme northeastern boundary. This stream meanders through a rather wide flood plain that is subject to local overflows. The present level of the valley floor is 70 or 80 feet below that of the bordering uplands. Small creeks and drainage ways ramify all parts of the uplands, except practically level areas in the vicinity of Milo and Liberty Center. Drainage in the flat areas is poor, and tiling is necessary for best farming results. Throughout the undulating or moderately rolling sections drainage is usually sufficient, but even here it has proved advantageous to tile the depressions and swales. The rougher sections adjacent to streams suffer from erosion and should never be left without cover. Practically all the first bottoms are subject to inundation in time of extreme overflow, but since the rivers and many of the creeks have been straightened and ditched this menace has been largely overcome and crops seldom suffer from excess moisture.

Most of the farms of the county are supplied with water obtained from bored wells. In the uplands good water is reached at a depth ranging from 175 to 200 feet, but in the bottom lands most of the wells are much shallower.

According to the 1920 census, the population of Warren County is 18,047. The total urban population is given as 3,628. The rural population is 14,419, an average of 25.3 persons to the square mile.

Indianola, with a population of 3,628, is the county seat and principal town. Simpson College is located here, as are also a produce house, several factories, and a creamery. Carlisle, in the northeastern part of the county, has a population of 640 and is an important tile and brick manufacturing center. Milo, with a population of 560; Lacona, with 502; New Virginia, with 424; Norwalk, with 331; Hartford, with 218; and Martensdale, with 100, are smaller railroad towns. Other towns of local importance are Ackworth, Beech, Ford, Palmyra, Liberty Center, St. Marys, Wick, Conger, Spring Hill, Lida, Cumming, and Orillia.

Warren County was organized in January, 1849. The early settlers came mainly from States to the east and south. Later a number of foreign-born, mostly German and Irish, immigrants moved in and took up lands. At the present time, however, the entire population is made up of native-born Americans.

Warren County is served by three railroads, the Great Western, the Chicago, Rock Island & Pacific, and the Chicago, Burlington & Quincy. The main line of the Great Western Railway, which runs from Des Moines to Kansas City, crosses the western part of Linn and Jefferson Townships. A branch of the Chicago, Burlington & Quincy Railroad serves the western half of the county. This road passes through Norwalk, Martensdale, and St. Marys and leaves the

<sup>1</sup>GANNETT, HENRY. A DICTIONARY OF ALTITUDES IN THE UNITED STATES. (FOURTH EDITION.) U. S. Geol. Survey Bul. 274, 1972 p. 1906.

county just south of the center of the western boundary, but again loops back into the extreme southwestern corner and passes through New Virginia. Another branch of this same system runs across the extreme northeastern corner and closely follows the Des Moines River bottoms. Another branch enters the county from the south, passes through Lacona, Milo, and Ackworth, and terminates at Indianola. The Chicago, Rock Island & Pacific Railway enters the county just north of Carlisle where it divides, one branch extending southeastward through Hartford and Beech and the other closely following the bottoms of Middle River. The last-mentioned branch passes through Summerset, Spring Hill, and Martensdale, and a spur line joins Summerset and Indianola. In addition to the railroads, bus lines radiating from Des Moines serve a large number of towns.

Warren County has a complete system of improved dirt roads. These roads either follow land lines or are parallel to them, except in the rougher sections adjacent to the larger streams. Although no hard surfacing has been done, except in short stretches in the vicinity of Carlisle and Norwalk, the principal county roads have been brought to grade. Tiling has also been done where necessary, fences put up along dangerous fills, and permanent culverts and bridges constructed. The transcontinental Jefferson Highway crosses the county in a north-and-south direction and passes through Indianola. In dry weather the roads are very good, but rains soon cause travel to become slow, difficult, and in many places dangerous. Most of the roads are dragged immediately after rains.

Telephone lines and rural mail routes serve all parts of the county. Electric transmission lines, radiating from Indianola, furnish current to a number of farms and villages. Churches and schools are conveniently located throughout the county, and in some townships consolidated schools have been established. Des Moines, Omaha, and Kansas City are the principal outside markets.

#### CLIMATE

The climate of Warren County is typical of that of south-central Iowa. It is marked by wide and often sudden changes in temperature. The summers are usually hot and the falls are cool and pleasant. These features favor the production and harvesting of corn, oats, wheat, and hay. The mean temperature for the summer is 72.8° F. and that for the fall is 51.7°. Extremes of 109° and 111° have been recorded in July and August, respectively, but hot spells are usually of short duration and growing crops are seldom injured. The greatest damage is done when the hot spells are accompanied by hot winds from the southwest. The winters are long and often severe, though periods of moderate temperature occur. The mean winter temperature is 23.3° and an absolute minimum of -32° is recorded in January. The mean annual temperature is 49.2°.

The mean annual rainfall of 32.97 inches is well distributed for agricultural purposes. The records show that the greatest amount of precipitation occurs during the growing season, from May to September. Most of the summer rain falls as thundershowers, though wet spells of two or three days duration are not uncommon when a low-pressure area prevails over the State. Early spring rains occasionally delay corn planting but not sufficiently to prevent the grain from

maturing. As a rule, the precipitation is rather low in the fall. This feature is very favorable for harvesting the crops. The year of this survey (1925) was an exception to this rule, when rains continuing from October to the Christmas holidays hampered farming operations. Hailstorms are rare, and the damage caused by them is local.

The precipitation during winter usually occurs as snow, and the average annual snowfall is 27.6 inches. Snow frequently blankets the ground for a long time. This protection prevents winter wheat and alfalfa from freezing.

The average date of the last killing frost is April 25 and of the first is October 8. This gives an average frost-free season of 166 days. The latest recorded killing frost occurred on May 19 and the earliest on September 20. The grazing season continues from about the middle of April to the last of October.

Table 1, compiled from records kept by the United States Weather Bureau station located at Indianola, gives the normal monthly, seasonal, and annual temperature and precipitation.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Indianola

[Elevation, 972 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1894)	Total amount for the wettest year (1902)	Snow average depth
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December.....	26.3	64	-23	1.45	0.90	2.95	6.0
January.....	20.4	63	-32	1.21	.68	.84	7.2
February.....	23.1	66	-28	1.19	.77	.72	7.3
Winter.....	23.3	66	-32	3.85	2.35	4.51	20.5
March.....	35.6	87	-10	1.56	.99	1.12	4.3
April.....	50.5	91	14	3.21	1.79	1.61	.9
May.....	61.6	93	21	4.49	1.43	5.54	Trace.
Spring.....	49.2	93	-10	9.26	4.21	8.27	5.2
June.....	70.3	100	41	4.46	1.29	6.50	0
July.....	75.1	109	48	3.74	.40	7.25	0
August.....	72.9	111	39	4.28	.95	9.48	0
Summer.....	72.8	111	39	12.48	2.64	23.23	0
September.....	65.0	99	23	3.42	4.53	5.45	0
October.....	52.9	89	15	2.48	1.09	3.25	.2
November.....	37.1	78	1	1.48	.83	2.59	1.7
Fall.....	51.7	99	1	7.38	6.45	11.29	1.9
Year.....	49.2	111	-32	32.97	15.65	47.30	27.6

#### AGRICULTURE

The agricultural development of Warren County began in 1845 when the first claim was taken up just north of the present town of Palmyra. During the next few years the influx of pioneers was slow, and most of them built their homes in the timbered areas adjacent to streams where water was easily accessible and the trees afforded protection from the cold winds of winter. These pioneers spent most

of their time in trapping, as game was plentiful. They cultivated only sufficient land to supply some of the necessities of the home. As the population increased, more land was reclaimed and planted to the staple crops. Corn and wheat were the principal crops, but some oats, barley, and rye also were grown. Some farmers sowed flax for a year or two on freshly broken sod. The luxuriant grass vegetation of the prairies soon lead to an increase in the raising and feeding of cattle.

Prior to the building of the railroads the marketing of products was difficult and often impractical. This curtailed production, and no crops were grown except for home use. The coming of the railroad, however, put new life into all farming activities. Many new settlers moved into the county, the size of farms increased, improved cultural methods were put in practice, and greater numbers of cattle and hogs were raised.

Tables 2 and 3, compiled from statistics grouped in the census reports of 1880, 1890, 1900, 1910, and 1920, show at a glance the agricultural development in Warren County during the last 40 years.

TABLE 2.—*Farm areas and tenancy*

Year	Number of farms	Land in farms	Farm land improved	Farms operated by owners	Farms operated by tenants
		<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
1880 .....	2,617	89.1	82.9	75.0	25.0
1890 .....	2,613	91.3	86.6	70.9	29.1
1900 .....	2,926	96.4	81.6	65.8	33.7
1910 .....	2,608	93.7	88.0	67.1	31.9
1920 .....	2,402	92.5	84.2	63.1	35.3

TABLE 3.—*Acreage and production of principal crops in 1879, 1889, 1899, 1909, and 1919*

Crop	1879		1889		1899		1909		1919	
	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>
Corn .....	100,080	4,419,556	84,342	4,078,982	102,255	3,960,020	81,523	2,715,239	67,008	2,410,254
Wheat .....	38,512	404,809	4,430	52,183	9,183	132,240	7,373	113,697	53,896	969,840
Oats .....	13,730	452,417	31,898	1,255,067	31,578	1,052,960	21,634	508,924	20,020	550,267
Rye .....	945	15,088	567	10,121	1,020	12,260	323	4,008	855	9,402
Hay .....		<i>Tons</i>		<i>Tons</i>		<i>Tons</i>		<i>Tons</i>		<i>Tons</i>
	22,218	40,671	55,920	81,196	47,365	67,280	50,572	73,216	26,958	37,734

The total number of farms in the county for the 40-year period from 1880 to 1920 shows a decrease of 215, though an increase of 313 is recorded for the decade from 1890 to 1900. During the 40-year period the average value of all farm property increased from \$3,693 to \$29,749.

Corn has always been the most important crop. The 1880 census reports an average yield of 44 bushels to the acre in 1879, owing no doubt to the inherent richness of the soils rather than to good methods of cultivation. The next three decades show a gradual decrease in the acre yield, but there was a slight increase, about 2 bushels to the acre, for the period 1909 to 1919. The decrease was probably caused by poor cultural methods. In the early days wheat was an important cash crop and yields of 25 and 30 bushels were commonly

obtained on the new ground. Lack of proper crop rotations soon impaired these yields, and in 1879, according to the 1880 census, the average production was only 10 bushels to the acre. During the next decade a comparatively small acreage was devoted to this crop, though a slight increase in acre yield is noted. The 10-year period 1910 to 1920, however, shows a decided increase both in acreage and in yield.

The agricultural growth of Warren County is reflected largely in the increased values of all products sold from the farms. For example, the estimated value of animals sold or slaughtered increased from \$1,354,057 in 1899 to \$3,610,965 in 1919.

The agriculture of Warren County at present consists of the production of corn, wheat, oats, hay, and all crops adapted to this section of the country, in conjunction with the raising and feeding of cattle and hogs. Dairying and sheep raising are less important livestock industries. Practically all the hay and grain, with the exception of wheat, is used as feed on farms within the county.

Corn is the most important crop grown and occupies by far the largest acreage. The census of 1920 reports that 67,008 acres, which produced 2,410,254 bushels, or an average of 35.9 bushels to the acre, were devoted to this crop in 1919. The crop is practically all used within the county as feed for the work animals, beef cattle, and hogs. In some years a small surplus raised on the better farms is shipped to outside markets. In 1924 a total of 5 carloads was sold outside the county. However, the supply seldom equals the demand, especially in the eastern half of the county where more cattle are fattened. In this part of the county more than 45 carloads of corn were required in excess of the total amount raised during 1924. The selection of good seed is now considered of great importance. Reid Yellow Dent and strains of this variety are well adapted to the soils of this county and occupy the largest acreage. The white varieties—Boone County White, Johnson County White, Iowa Silvermine, and Silver King—are less popular. Some Leaming, a flint corn, is grown in certain localities.

Wheat ranks second in acreage, but it is the principal cash crop. In 1919, the 53,396 acres planted to this crop produced 969,840 bushels, or an average of 18.1 bushels to the acre. Much higher yields, however, were reported on the better farms. Approximately 90 per cent of the total wheat acreage is winter wheat, and the most popular varieties are Kanred and Turkey. Winter wheat, which is usually planted between September 20 and November 1, seldom winterkills. Spring wheat, which is usually a strain of Marquis, gives low yields and on this account occupies a very small acreage. Practically the entire crop is sold through the elevators and cooperative associations in Chicago, Kansas City, and Omaha markets.

Oats are grown on most farms and constitute the crop third in importance, according to the 1920 census. In spite of the fact that the crop fits well in the general rotation the acreage planted is comparatively small, probably because of the low average yield, which is 27.4 bushels to the acre. Practically the whole crop is consumed locally as feed, though a small percentage is occasionally sold through the cooperative elevators to outside markets. Kherson and its various strains, Albion (Iowa 103), Richland (Iowa 105), and Early Champion are the varieties most universally grown.



Hay and forage crops rank fourth in importance, though the acreage in 1919 was more than that of oats. The total acreage in tame and cultivated grasses, which amounts to 25,541 acres, is nearly double the combined acreage of wild or prairie grasses, grains cut green, coarse forage, and silage crops. Timothy and clover, grown separately or together, are most important. Because of its soil-improving properties, alfalfa is receiving more attention, and it is estimated that 1,502 acres will be devoted to this crop in 1926. Dakota No. 12 and Grimm are the favorite varieties. In 1919 the average acre yield for hay and forage crops was as follows: Alfalfa, 2.3 tons to the acre; timothy and clover, 1.7 tons; clover alone, 1.2 tons; and timothy, 1.09 tons. Red clover is extensively grown, but alsike and mammoth clover are also popular. Alsike is largely grown on the bottoms, where it gives best results. Sweet clover is increasing in importance. In the fall of 1925 a carload of seed was shipped into the county, and it is estimated that 1,115 acres will be planted to this crop in 1926. Sweet clover, like alfalfa, is a soil builder and is grown both for forage and green manure. All the hay is used on the farms as feed for the work animals, beef cattle, and dairy cows, and in many parts of the county the supply is not equal to the demand.

The census of 1920 reports that 3,213 acres, from which 22,374 tons of silage were cut, were devoted to silage crops in 1919. Corn constituted the greater part of this tonnage, though some soy beans and sorghum were included. The soy beans are usually planted with the corn by means of a special attachment on the corn planter.

Rye is a subsistence crop of little importance. In 1919 a total of 855 acres produced 9,402 bushels. This crop is all used as hog feed on the farms.

Barley ranks fifth among the cereals in acreage. The 619 acres planted to barley in 1919 produced 10,777 bushels, or an average of 17.4 bushels to the acre. The whole crop is used locally.

Sudan grass, kafir, and vetch are grown for forage to some extent. A few fields of sorghum to be used for the production of sirup were also observed. Buckwheat serves as an occasional catch crop, and a number of fields of rape are grown for hog pasture.

Small apple orchards are found on most farms. On a few farms the trees are well sprayed and excellent fruit is produced, but on most farms the orchards are neglected and the fruit is faulty. Jonathan, Winesap, Wealthy, and Fameuse (Snow) are the most common varieties.

Cantaloupes and watermelons are grown on many of the sandy areas throughout the county. Where the seed is selected and proper cultural methods are employed, melons of excellent flavor are obtained. The melons as a rule are sold in the near-by towns, but in the northwestern corner of the county, near Norwalk, a large quantity of melons is sent by truck to Des Moines.

Potatoes are grown on most farms for home use. The census reported a total yield of 17,714 bushels in 1919. Truck crops and small fruits are also produced to a slight extent to supply, in part, the local demand.

The principal livestock industry is hog raising. According to the Iowa Year Book for 1922 there were 90,154 hogs on the farms on January 1, 1923, and approximately one-fifth of this number were

brood sows. Most of the hogs are of mixed breeds, but an increasing number of farmers are attempting to keep only purebred animals.

The lard-type breeds, of which the Duroc-Jersey is the most popular, are preferred. The Poland China, Spotted Poland China, and Chester White follow in numbers in the order named. The Tamworth is the principal bacon breed. About two-thirds of the pigs are farrowed in in the fall and one-third in the spring. In some years cholera causes considerable loss. The 1922 Iowa Year Book reported a total loss of 4,536 pigs from this disease in 1922. It is common custom to fatten the hogs and sell them when they are between 6 and 10 months old, either through cooperative selling associations or in car lots by individual farmers. The principal markets are Chicago and Kansas City.

The raising and feeding of beef cattle ranks next to hog raising in importance. Although a number of animals are raised on the farms of Warren County, the common practice is to ship in feeders in the fall or early winter. The 1922 Iowa Year Book reported a total of 30,679 beef animals on the farms on January 1, 1923, or an average of 17 head to the farm. On many farms the number is much smaller, and in certain parts of the county, particularly the northern half, herds varying from 60 to 100 head are kept. Feeders prefer young cattle, and the general practice is to resell between 60 and 120 days after feeding is begun. The animals are first pastured or turned into the cornfields from which the grain has been husked, and are then finished on corn, silage, and hay. Occasionally the ration is supplemented by oil meal. Shorthorn, Hereford, and Angus, named in order of their importance, are the most popular beef breeds. The finished cattle are usually shipped by the individual farmers in car lots to Kansas City and Omaha, but a few farmers sell to buyers for outside markets.

Dairying is the livestock industry third in importance. According to the 1922 Iowa Year Book 9,030 milk cows were reported in the county on January 1, 1923. This industry is carried on as a side line on most farms, where 8 or 10 cows are kept. Near Indianola several farms are devoted entirely to dairying. In the northern half of the county the whole milk is collected and hauled to Des Moines, and in the southern and central parts surplus milk is sold at the creamery in Indianola. The most popular dairy breeds, named in order of their importance, are Holstein, Guernsey, and Jersey. Near Norwalk one of the best Holstein herds in the country is kept. Warren County is now listed in the tuberculosis-free area.

The raising and feeding of sheep is of minor importance and is usually carried on only in the rougher parts of the county. According to the 1922 State census 9,608 sheep of all ages were reported on farms on January 1, 1923, and during 1923, 3,310 western sheep were shipped in for feeding. The imported sheep are usually fed between three and five months. The native flocks are kept mainly for wool and during 1923, 46,946 pounds of wool were sold. Shropshire and Oxford are the most popular breeds.

According to the 1922 Iowa census there were 10,495 horses of all ages and 1,246 mules in the county on January 1, 1923. The universal practice among farmers is to raise several colts each year to help keep up the supply of work animals. Animals of the draft type predominate.

The production of chickens and eggs, although strictly a side line, is important. The United States census of 1920 gives the value of poultry and eggs produced in 1919 as \$713,604, and the 1922 Iowa census reports 302,590 chickens in the county on January 1, 1923, and an estimated production of 1,191,181 dozen eggs. The poultry and eggs are sold largely at the produce house in Indianola or to buyers who resell in Des Moines.

On most farms surface relief has had little effect on the production of general farm crops. The rougher farmed areas produce lower yields, owing mainly to erosion which is largely overcome in some places by the use of brush and concrete dams. The straightening and dredging of many of the rivers and creeks has also reclaimed much land that formerly was unfit for profitable agriculture.

The farmers of Warren County recognize that it is impractical to cultivate the rougher land adjacent to streams, and such areas are left for permanent pasture. Many of the poorly drained first bottoms are also left with their natural cover, as cropping would not be profitable. Except for wheat production the upland soils are not considered inferior to the bottom-land soils. Wheat usually gives best results on the heavier bottom land, where it takes the place of oats in the general rotation. In selecting alfalfa land, due consideration is given to drainage. The sandy areas are used exclusively for the production of melons and truck crops.

Cornland throughout the level or gently rolling parts of the county is usually plowed in the fall and disked and harrowed the following spring. The rougher areas are all plowed in the spring on account of the damage that would result from erosion if they were plowed in the fall. The soil is commonly plowed to a depth ranging from 4 to 6 inches, and the seed bed is generally well prepared. The planting season continues from April 20 to June 1, and replanting is seldom necessary. In some years late spring rains delay planting. This necessitates listing a small acreage of corn that is cut for silage. Practically all the corn is planted in checkrows, though a small acreage in the bottoms is drilled in, as such a method allows deeper planting. Soy beans are interplanted with much of the corn that is cut for silage. This practice greatly improves the feeding value of the silage. Corn generally receives four cultivations. Smartweed and foxtail are the most common weeds. Corn harvesting usually begins about October 15, and the greater part of the crop is husked in the field. In some places the crop is harvested with a binder and shocked in the field till feeding time, and a small acreage is hogged down.

Corn is usually grown for two or three years, sometimes longer, on the same land. After the grain is harvested cattle are turned in to pasture on the stalks and fodder. In the following spring the fields are thoroughly disked to break up the stalks and are then plowed and harrowed. A few farmers rake up and burn the stalks before plowing.

Winter wheat is grown on the fields where the corn has been cut for silage or harvested and shocked. Practically all the wheat is drilled in. A small acreage is drilled in between the corn rows with a 1-row drill. Seeding is done between September 20 and November 1. Nearly all the spring wheat is broadcast. Oats are sown in the spring, and where this crop follows corn much of the land is disked

twice and is then harrowed without plowing. This crop also is largely drilled in. Where clover or clover and timothy are included in the rotation, spring seeding with oats or wheat as a nurse crop is the common practice. Where clover is planted with wheat the seed is either broadcast in the fall and allowed to work into the ground through alternate freezing and thawing or is harrowed in during April. After the grain is harvested the clover and timothy attain sufficient growth to afford light pasturage in the fall. The following year the clover and timothy are either cut for hay or are pastured, after which the stubble land is left by some farmers as a foundation for permanent pasture.

Alfalfa, as a forage crop, is increasing in importance each year. More attention is given than formerly to the selection of seed and the soil on which the crop is grown. Approximately 80 per cent of the alfalfa is planted in the fall without a nurse crop. Spring seedings are always combined with oats or wheat. The rate of seeding is usually 15 pounds to the acre. Practically all fields are limed, and the seed is inoculated. One cultivation a year is usually given the crop, and for this purpose a spring-tooth harrow or disk harrow with half set is used. Alfalfa is cut from two to four times a season.

Manure is carefully saved on most farms and scattered over the stubble or grassland before plowing. It is used to some extent to fertilize the melon crop. A number of carloads of lime are shipped into the county each year, as its use has proved of great value. Lime not only increases yields but also improves the physical condition of the land. Green-manure crops are occasionally grown, but commercial fertilizers are not used. Nevertheless, the application of phosphates on similar soils in other counties of the State has proved an economically sound practice.

Most of the farm buildings are substantial, well kept, and conveniently arranged. Many homes are equipped with electricity and a few with running water. Most of the barns are large and afford ample storage space and housing for the work animals. There are sufficient corncribs to hold normal yields, but during bumper years much grain is stored in the open in wire bins. The 1922 census reported 289 silos in Warren County. Most farms are well fenced, barbed wire being the favorite fencing material.

Improved farm machinery, including gang plows, disk plows, section harrows, disk harrows, 1-row and 2-row cultivators, grain drills, corn planters, mowing machines, corn binders, hayrakes, hay loaders, reapers, threshers, and hay stackers, is in general use. The 1922 census reported 194 tractors and 105 trucks in the county. Small gas engines are used on a number of farms for pumping water and for miscellaneous purposes. A few windmills are still in use.

The labor problem is a difficult one, and competent farm help is hard to obtain. Practically all laborers are native whites. Single men are paid \$35 or \$40 a month with board, and married men usually receive \$50 a month in addition to a house, a garden site, a cow, and chicken feed. During the husking season of 1925, corn pickers received 6 cents a bushel and their board. The 1920 census reports that an average of \$393.83 to the farm was expended for labor in 1919.

The 1920 census reported that 63.1 per cent of the farms were operated by owners, 35.3 per cent by tenants, and 1.6 per cent by managers. The tenants rent in various ways. Cash rents range

from \$6 to \$12 an acre, depending on the condition of improvements and the location of the farm. Other methods, more or less in vogue, consist of the grain and stock share plans. Under the grain-share system the tenant receives one-half the corn and two-thirds the small grain, and he furnishes the seed, work animals, and labor. The land-owner always purchases the clover seed and receives half the hay. The stock-share plan differs in that the owner and tenant share equally the cost of feeders and divide all revenues equally.

The census of 1920 reports the average size of farms as 140.5 acres, 84.2 per cent of which is improved land. Much larger holdings are found in some parts of the county. Near the towns, farms ranging in size from 40 to 90 acres are more numerous.

It is hard to obtain definite land values at present because few farms have changed hands within the last year or so. In the vicinity of towns well-drained and improved soils such as Tama silt loam, Grundy silt loam, and Muscatine silt loam range in value from \$175 to \$225 an acre. The Shelby and Lindley soils, which are predominantly rough and strongly rolling, are valued much lower, commanding from \$75 to \$125 an acre. The improved well-drained bottom-land soils command from \$150 to \$200, and the unimproved timbered areas may be bought for about half that amount.

#### SOILS <sup>2</sup>

The soils of Warren County have developed under prairie conditions, with the exception of a few comparatively small more or less isolated areas where better drainage and more thorough aeration has encouraged forest growth. The native vegetation under which the soils were developed was grass on the level or moderately rolling areas and timber along the rougher belts and adjacent to the larger streams.

The greater part of Warren County has, from the earliest time, been covered by a luxuriant growth of grass, a vegetation that flourished under the influence of an abundant moisture supply. With the decay of these grass roots year after year, large quantities of finely divided carbonaceous material have been thoroughly mixed with the mineral constituents. Consequently the soils have a predominantly dark color, a characteristic peculiar to soils developed under prairie conditions. The content of organic matter, the depth to which it extends, and the influence it has had on the physical condition of the soil are largely the results of drainage. Throughout the flat or gently undulating areas, where the downward movement of water is not restricted, the dark color continues to a depth ranging from 18 to 22 inches. Even at a depth varying from 24 to 30 inches dark splotches, caused no doubt by the infiltration of the finely divided carbonaceous matter along old root channels, were observed. Throughout the more rolling parts of the county and in areas where erosion has been more active the dark color may not continue to a depth of more than 5 or 7 inches.

<sup>2</sup> Warren County adjoins Polk County on the north and Madison County on the west. In a few places the soil maps do not agree. Small areas of soil in Warren County adjoining large areas in the counties named were not continued in Warren County but were combined with similar soils; for instance Chariton silt loam in Polk County is mapped as Calhoun silt loam and Lindley loam in Madison County is mapped as Lindley silt loam in Warren County.

The group of mature soils that have been formed under conditions of good drainage includes the various members of the Tama, Carrington, and Shelby series in the uplands and of the Waukesha and Judson series on the terraces. A typical profile of this group of soils shows a dark-brown or very dark brown surface layer, 16 or 18 inches thick, having a fine granular structure. In the few virgin areas seen along fence rows where cultivation was impossible the soil, to a depth of 2 or 3 inches, seems to have a platy or finely laminated structure and is somewhat lighter colored than the soil in cultivated areas. Below a depth of 3 inches and continuing to a depth of 14 or 16 inches the subsurface layer is typically dark brown in color and finely granular in structure. The upper subsoil layer consists of yellowish-brown silty clay loam which, when dry, breaks down to a mass of subangular particles measuring one-sixteenth or one-eighth inch in diameter, forming a so-called small nut structure. The color, texture, and structure of this layer remain fairly uniform in most areas to a depth of 32 or 34 inches. The lower part of the subsoil, between depths of 32 and 60 inches, differs from the upper part in that it contains gray mottles, the number of which increases perceptibly with depth. A few iron stains also are noticeable in this layer. At an approximate depth of 60 or 65 inches the parent material, which consists of mottled gray, brown, and yellow heavy silt loam, is reached. In the upper part the substratum has a somewhat platy structure but below the 6-foot depth it is practically structureless. With the exception of the Shelby soils, soils of this group have been thoroughly leached and the carbonates entirely removed to a depth of 3 feet, and most of the soils show an acid reaction. The carbonates found in most of the lower subsoil layers of the Shelby soils seem to be the result of more recent exposure rather than lack of leaching. The Judson soils, although developed under similar conditions, differ slightly in profile characteristics in that they are more porous. Consequently the carbonaceous material has been carried to a greater depth, and the soil to a depth of 3 feet is dark brown in many places.

The dark-colored prairie soils which have been formed under poor or restricted drainage conditions comprise another group. These soils have surface layers varying from very dark brown to almost black. The soil to a depth of a few inches has a rather indefinite laminated or fine platy structure which is hidden by the mass of grass roots contained. In cultivated areas the entire surface layer is a dark-brown finely granular mass. The subsoils are gray, dark gray, or mottled gray, brown, and yellow and generally are much heavier than the surface soils. Profile characteristics of this group vary with drainage conditions, which have influenced the degree of leaching, oxidation, and aeration. Throughout the more extensive areas of the Grundy soils the surface soil is underlain, at a depth of 18 or 20 inches, by a dark grayish-brown or dark brownish-gray layer, which in most places is silty clay loam. At a depth varying from 22 to 26 inches this layer grades rather abruptly into compact heavy gray, brown, and yellow silty clay which is mottled with iron-oxide splotches. The subsoil structure apparently ranges from coarsely granular in the upper part to nutlike below a depth of 3 feet. The lower part of the 3-foot section becomes more friable and grades, at a depth of 4 or 5 feet, into the parent material, which is gray heavy silt loam or silty

clay loam, mottled with dark gray, brown, and yellow. The different members of the Muscatine series, which are found throughout the gently undulating uplands, have been formed under slightly better drainage conditions than the Grundy soils and occupy an intermediate position between the Tama and Grundy soils. The surface soils and upper subsoil layers have been formed under moderately good drainage conditions, but drainage below the 27-inch depth has been somewhat restricted. The result is more thoroughly oxidized surface soils underlain, at a depth of 2 or 2½ feet, by slightly mottled subsoils. Included in the general group of soils developed under conditions of excessive moisture are the Bremer soils of the terraces and the Wabash soils of the first bottoms.

Originally Warren County was no doubt entirely covered with a luxuriant grass vegetation. With the passing of time erosion was active along some of the larger streams and this resulted in better drainage, which allowed more through oxidation, leaching, and aeration. Consequently the grass vegetation disappeared and in its place forests sprang up. The spread of forest growth would no doubt have continued had it not been for the advent of man and the reclamation of the prairies. Soils formed under forest conditions are naturally low in organic matter and are light colored. The light-colored soils, therefore, are found to be almost coextensive with the areas covered by forests at the time of settlement, except those areas of alluvial soils which consist of reworked materials washed from the light-colored upland soils. The forested soils have light-brown or grayish-brown floury surface layers, 6 or 8 inches thick, underlain by a finely granular heavier textured layer which continues to a depth of 18 or 20 inches. Below this depth the material is tough and compact and breaks up to coarse subangular granules, many of which are covered with a thin grayish film. The texture becomes lighter and less compact below the 34-inch depth, and the layer merges gradually with the parent material, which is typically gray, heavy, friable silt loam or silty clay loam mottled with rust brown, gray, and yellow. Some iron stains are also present. The Clinton and Lindley soils of the uplands and the Jackson and Calhoun soils of the terraces belong to this group. The different members of the Genesee and Sarpy series of the flood plains have been formed under similar conditions.

The natural soil-forming forces, leaching, oxidation, and aeration, have undoubtedly exerted the greatest influence on soils of this county and are responsible in large measure for their present characteristics. However, in the separation of these soils into series and types, due regard has been given to the composition, source, and process of formation of the parent materials.

For instance, the soils of the Tama series are upland soils formed on loess under conditions of good drainage, whereas the Carrington and Shelby soils, formed under similar conditions, are derived from glacial drift. Soils of the Waukesha series resemble closely those of the Tama and Carrington series but differ in that the Waukesha soils are formed from reworked material washed from dark-colored upland soils and are now above the reach of overflow. The Judson soils also occupy a terrace position.

The Grundy and Muscatine soils are dark-colored upland soils that have been derived, through weathering, from loess. Unlike the soils of the Tama series, however, they have been formed under

conditions of poor or restricted drainage, and their profile characteristics are different. The Bremer soils of the terraces and the Wabash soils of the first bottoms have similar profiles and were differentiated solely on account of their position.

The light-colored soils of the uplands, although similar in profile characteristics, have been separated into two series on the basis of origin. The soils of the Clinton series are formed on loess, whereas the Lindley soils are derived through weathering from underlying glacial drift. In like manner we have the Jackson and Calhoun soils of the terraces, and the different members of the Genesee and Sarpy series, which have been formed on the more recent flood-plain deposits and consist of material washed from the light-colored uplands.

As stated above, the soils of Warren County have been grouped in series on the basis of origin, color, structure of surface soil and subsoil, and method of accumulation. These series have been divided into soil types on the basis of the texture of the surface soils. The soil type is the unit of classification and mapping. The soils of Warren County have been separated into 26 soil types, which represent 15 soil series. The different soils are discussed in detail in the following pages. Detailed descriptions of the profile are given, as well as of variations that occur within the soil.

Table 4 gives the name, acreage, and proportionate extent of each soil mapped. The accompanying map shows the distribution of the different soils in Warren County.

TABLE 4.—*Acreage and proportionate extent of soils mapped in Warren County, Iowa*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Tama silt loam.....	88,960	25.1	Bremer loam.....	192	0.1
Shallow phase.....	2,624		Judson loam.....	192	.1
Grundy silt loam.....	40,384	11.1	Calhoun silt loam.....	512	.1
Muscatine silt loam.....	21,568	5.9	Jackson silt loam.....	192	.1
Clinton silt loam.....	9,856	2.7	Wabash silt loam.....	42,240	11.6
Carrington silt loam.....	12,736	3.5	Wabash silty clay loam.....	7,744	2.1
Carrington loam.....	8,384	2.3	Wabash silty clay.....	1,152	.3
Carrington fine sand.....	448	.1	Wabash loam.....	192	.1
Shelby loam.....	106,304	29.1	Genesee silt loam.....	448	.1
Shelby silt loam.....	3,392	.9	Sarpy silt loam.....	1,088	.3
Lindley silt loam.....	5,696	1.5	Sarpy very fine sandy loam.....	640	.2
Waukesha silt loam.....	2,752	.8	Sarpy fine sandy loam.....	576	.1
Waukesha loam.....	256	.1			
Bremer silt loam.....	5,952	1.6	Total.....	364,800	-----
Bremer silty clay loam.....	320	.1			

#### TAMA SILT LOAM

The surface soil of Tama silt loam, in the few virgin areas, consists of very dark grayish-brown or almost black friable silt loam, 2 or 3 inches thick. This layer is underlain, to a depth ranging from 14 to 18 inches, by material which is somewhat darker in color and which has a true granular structure. The upper subsoil layer, which continues to a depth ranging from 24 to 30 inches, is brown or yellowish brown and is typically lighter colored than either of the layers above. On the other hand, the texture of the subsoil is much heavier, ranging from heavy silt loam to silty clay loam. The material is somewhat friable in consistence and has a small nut structure, the subangular particles measuring from one-sixteenth to one-eighth inch in diameter.



The lower subsoil layer, which is in most places  $2\frac{1}{2}$  or 3 feet thick, differs from the layer above in that faint gray mottles and iron stains occur and gradually increase in number with depth. Below this layer is the parent material, consisting of brown, yellowish-brown, or yellow heavy silt loam, faintly mottled with gray. In the upper part of the substratum the structure is somewhat platy but at a greater depth the mass is practically structureless. These soils have been leached of carbonates to such an extent that no effervescence was observed with dilute acid, even in the deepest cuts. The cultivated areas, which constitute approximately 95 per cent of the total area of this soil in the county, differ from the foregoing description in that the surface soil, to a depth varying from 14 to 18 inches, is friable silt loam, brown or dark brown when dry and dark brown or almost black when wet.

The profile of Tama silt loam is rather uniform throughout the county, the only variations occurring where this soil is associated with Grundy and Muscatine soils. In transition zones along such boundaries, the lower part of the subsoil is more strongly mottled with rust-brown iron stains. Included in mapped areas of Tama silt loam are very small patches of Muscatine silt loam and Grundy silt loam of such slight importance that separation was considered unnecessary.

Tama silt loam is the predominant upland soil north of an arbitrary east-and-west line through Indianola, and smaller isolated areas occur in the southern part of the county. In the northern half the areas are extensive and are broken only by narrow ribbonlike patches of Carrington silt loam and Carrington loam along the lower slopes of streams and Wabash silt loam bordering the streams.

The greater part of this soil is undulating or gently rolling. Even throughout areas of greatest relief, in the vicinity of Hartford in the northeastern corner of the county and Martensdale near the western boundary, the hill crests are rounded and the slopes even. The runoff, although sufficient, is not active enough to cause serious erosion. Both surface soil and subsoil are naturally well drained, and the subsoil is retentive of moisture.

Tama silt loam is considered a valuable agricultural soil and is practically all under cultivation or in pasture. Corn occupies the largest acreage. Wheat, oats, clover, and timothy, named in the order of their importance, are also grown. With the exception of wheat, all the grain and hay are used on the farms as feed for the work animals and cattle, and the supply is seldom equal to the demand. Wheat constitutes the chief cash crop and is sold in outside markets. Hog raising is the most important livestock industry, and the raising and feeding of cattle is second. Eight or ten milk cows are commonly kept on farms on this soil, and after the demands of the home have been satisfied the surplus whole milk is sold to creameries located at Indianola and Des Moines. A few sheep are raised for wool and for sale.

Yields<sup>3</sup> of corn average 39 bushels to the acre, though, during favorable seasons, maximum yields of 90 bushels have been reported by the more progressive farmers. Wheat yields from 18 to 28 bushels to the acre, oats from 35 to 60 bushels, and hay from 1 to 2 tons.

---

<sup>3</sup> Crop yields based on information obtained from farmers.

Tama silt loam in general receives very good treatment. Practically all small-grain stubble land and sod land is plowed in the fall, as fields are seldom damaged by winter rains. The corn stover remaining after the grain is harvested is used for forage. In the spring the cornstalks are cut with a disk harrow, and the fields are then broken and prepared for corn and small grain. The depth of plowing ranges from 4½ to 6 inches and in general the seed bed is put in a good pulverulent condition. Cultivation of the different grain and hay crops is generally sufficient to conserve moisture, combat weed pests, and promote growth. Crop rotations are in more or less general use. A 5-year rotation consisting of corn, corn, oats, wheat, and clover is popular, though most farmers prefer the 4-year rotation of corn, corn, oats or wheat, and clover. Winter wheat follows corn where the latter crop is cut for silage, and a small acreage is seeded between the corn rows with a 1-row drill.

This soil is acid and ground limestone in increasing quantities is being used, especially where alfalfa, sweet clover, and red clover are to be profitably grown. Where available, stable manure is used on the grassland and stubble land before plowing. Commercial fertilizers are not used.

The value of land of this kind ranges from \$175 to \$225 an acre, depending on general surface features, improvements, and location with reference to towns, railroads, and roads. However, little land changed hands during the year of the survey (1925).

Tama silt loam is considered a valuable agricultural soil. On farms where systematic crop rotations in which legumes play an important part are followed, in conjunction with the raising and feeding of livestock, the fertility of the land is conserved and even increased. Improved cultural methods should be in use on all farms. It is further recommended that a larger part of each farm be seeded to some good legume, such as red clover, sweet clover, or alfalfa each year.

*Tama silt loam, shallow phase.*—Tama silt loam, shallow phase, differs from the typical soil in the depth and color of the surface layer and in the lack of gray mottles near a depth of 3 feet. In the few remaining virgin areas, the soil consists of brown or dark-brown silt loam, 2 or 3 inches thick, full of a mass of grass roots and fibers. This layer grades into a brown or medium dark-brown finely granular layer which continues to a depth varying from 6 to 10 inches. The true subsoil rather abruptly underlies the subsurface layer. It is yellowish-brown heavy silt loam which, at a depth of about 24 inches, is underlain by a lower subsoil layer of light yellowish-brown silty clay loam. Both subsoil layers have a nut structure. Cultivation mixes the surface layers, and plowed fields have a uniform brown or dark-brown color, silty texture, and finely granular structure, continuing to a depth varying from 6 to 10 inches. When wet the soil is much darker.

Soil of this phase occupies a comparatively small total area and occurs only in the northern third of the county. The most extensive areas are along the Polk County line north of Cumming and along the south side of Butcher Creek just west of Palmyra. The surface is more rolling than that of the typical soil. The thinner surface layer of this soil is caused by excessive surface drainage.

Approximately half of this soil is still in its natural condition and is used for pasture. The few fields that are cultivated in conjunction

with typical Tama silt loam respond well to cultivation, though yields are slightly lower than on the typical soil.

Erosion is a serious menace, and in handling the soil of this phase much more care must be exercised than with the typical soil. Plowing should be at right angles to the slopes, as this will prevent surface wash to some extent. It is also best to leave the fields with cover during the winter. All gullies should be dammed with brush or concrete dams, a practice that is now in use on the better farms.

#### GRUNDY SILT LOAM

Typical Grundy silt loam, in Warren County, has a very dark grayish-brown surface layer 3 or 4 inches thick which has a somewhat platy structure. The subsurface layer, which continues to a depth of 10 or 12 inches, is slightly darker colored and has a finely granular structure. This darker color is probably caused by the accumulation of greater quantities of carbonaceous material. Below this layer is a third layer, 6 or 8 inches thick, which has a finely granular structure. The particles appear black, owing to the presence of a thin coating, but when they are crushed between the fingers the mass is rust brown or dark grayish. The lower subsoil layer, which begins rather abruptly at a depth of 18 or 20 inches and continues to a depth varying from 24 to 28 inches, consists of dark grayish-brown or slate-colored heavy plastic silty clay. The mass breaks down into subangular nutlike particles which are coated more or less with a dark-brown or black film. This layer grades into mottled gray, rust-brown, and yellow somewhat crumbly silty clay, in most places 10 or 12 inches thick, which is mottled with bright-yellow splotches and iron stains. Below this layer and continuing to a depth of nearly 5 feet the soil aggregates decrease in size, the texture becomes less heavy, and the color is predominantly drab and yellowish gray. The parent material consists of gray structureless heavy silt loam splotched with dark brown and yellow. Minor variations in the thickness of the surface layer and in the color of the upper subsoil layer occur in different parts of the county.

As little of this soil remains in the native condition, observations of the virgin soil were few. Plowing has altered the soil to a depth of only a few inches, and the surface soil commonly consists of dark-brown or almost black friable silt loam 16 or 18 inches thick. The content of organic matter is high, and when wet the fields appear decidedly black. Grundy silt loam is associated with Muscatine silt loam in many places, and the transition from one soil to the other is so gradual that separation was necessarily arbitrary. Where bordered by Tama silt loam and Shelby loam, boundaries could be more sharply drawn.

Grundy silt loam, with the exception of a few small isolated areas in the northern part of the county, occurs only in the eight southern townships. The most extensive areas are in the southeastern quarter in the vicinity of Milo and Liberty Center. The surface is flat or gently undulating, and natural drainage is insufficient. Consequently much tiling has been done.

This is considered a strong agricultural soil, especially where it is properly drained. Therefore the greater part, approximately 95 per

cent, is devoted to the production of staple crops or is used as pasture land. The only tree growth is a few willows along old fence rows, Osage-orange hedges, and windbreaks that have been set out to the north and west of farm dwellings.

Corn is the principal crop and occupies the largest acreage. The grain is all used on the farms as feed for the work animals, beef cattle, and hogs. Wheat ranks second and oats third in importance. Wheat is the principal cash crop and is all shipped through the elevators to outside markets, whereas oats are used locally for feed. A large acreage of hay, mostly timothy and clover, is grown for use on the farms. Barley and rye are occasionally included in the crop rotation, and several fields of rape were observed. This crop is sown with oats or corn and is used for hog pasture. A growing practice is to seed soy beans with the corn that is to be cut for silage. This not only increases the feeding value of the silage but also enriches the soil. Alfalfa is grown on a few farms, and the fields are limed and the seed inoculated. The few apple orchards observed produced faulty fruit, owing to lack of care. Garden vegetables and small fruits are produced to supply, in part, the home needs.

The principal livestock industry is hog raising, and 50 or 60 pigs to the farm are raised yearly. The raising and feeding of beef cattle is also an important industry, and each fall a number of feeders are shipped in to augment the herds. The animals are resold within a period ranging from 60 to 120 days. Dairying and sheep raising, which are mainly carried on as a side line, follow in importance in the order named.

Crop yields are variable, as they depend largely on drainage conditions and the character of tenure. Corn yields average between 37 and 40 bushels to the acre, though yields of 80 and 90 bushels have been reported from improved farms. Under average conditions wheat produces from 18 to 25 bushels to the acre, oats from 40 to 55 bushels, and hay from  $1\frac{1}{2}$  to 2 tons.

Grundy silt loam is managed in much the same way as Tana silt loam, except that greater care is exercised to plow under proper moisture conditions. Fall plowing of all stubble land and sod land is preferred, and the seed bed is generally well prepared by thorough disking and harrowing.

This soil has a naturally poor circulatory system, and artificial drainage is very necessary. Many fields have been tiled, and the excellent results obtained indicate that this practice should be widely extended. Owing to the imperviousness of the subsoil, the laterals should be placed close together and as near the surface as is consistent with good practice. Both surface soil and subsoil give an acid reaction, and the use of ground limestone is strongly recommended. Crop rotations in which legumes play an important part and the turning under of an increased acreage of green-manure crops would also greatly improve the physical condition of this soil.

The price of this kind of land ranges from \$150 to \$200 an acre, depending on location and improvements.

#### MUSCATINE SILT LOAM

The surface soil of Muscatine silt loam is very dark brown mellow friable silt loam 18 or 20 inches thick. It is finely granular in structure and the soil particles are the size of bird shot. When wet the

soil appears nearly black. The upper subsoil layer, which in most places is 8 or 10 inches thick, consists of yellowish-brown or brown silty clay loam faintly mottled with gray. It has a coarse granular or nut structure. The subangular particles, where undisturbed, are much darker in color, owing to the presence of a very thin film of carbonaceous material over them. The lower subsoil layer begins at a depth of 28 or 30 inches and continues to a depth of 45 or more inches. It consists of mottled gray, rust-brown, and yellowish-brown silty clay which contains a few iron stains and iron concretions. Like the overlying layer it has a nut structure though the aggregates decrease in size with depth. Below a depth between 45 and 60 inches is the parent material. The predominating color of the substratum is gray with mottles of rust brown and yellow.

This soil has been leached of carbonates throughout. In the flatter areas the surface soils are thicker, varying from 20 to 22 inches, and mottles near a depth of 3 feet are more pronounced. Where the surface is slightly rolling and sheet erosion has been active the surface covering has been thinned and is slightly lighter in color than typical. In many places the transition between this soil and Tama silt loam was so gradual that the boundary lines were difficult to indicate. Included with mapped areas of this soil are a few areas of Tama silt loam and Grundy silt loam too small and unimportant to separate on the map.

Muscatine silt loam is extensive in all parts of the county. It occurs mainly on the narrow, level, or undulating divides. The more continuous areas are in the vicinity of Cool and Medford. The land varies from level to undulating. Surface drainage is usually sufficient for crop needs, but the subsoils are retentive of moisture and the movement of the water in the subsoil is seldom adequate for best results.

Muscatine silt loam is considered a valuable agricultural soil, and practically 90 per cent of it is in cultivated fields or pastures. Tree growth consists only of a few Osage-orange hedges and windbreaks to the north and west of farm dwellings.

Corn, wheat, oats, and hay are the principal crops, named in the order of their importance. All the grain, except wheat, which is the only cash crop, is used on the farms, and the supply is seldom equal to the demand. The hay crop consists principally of clover and timothy grown separately or together. Barley, rye, buckwheat, sorghum, and rape are less important crops. The acreage of alfalfa is increasing, and excellent yields are obtained. Bluegrass thrives and affords pasturage for the few head of cattle commonly kept. Hog raising is the principal livestock industry.

Yields on this soil equal those obtained on Grundy silt loam. Corn yields between 35 and 41 bushels to the acre, wheat between 18 and 26 bushels, oats between 35 and 55 bushels, and hay  $1\frac{1}{2}$  or 2 tons.

Improved land of this kind is held by the farmers at prices ranging from \$175 to \$200 an acre, depending on the location with reference to towns and railroads and on the condition of improvements.

Muscatine silt loam is managed in much the same way as the adjoining Grundy silt loam and Tama silt loam. It requires heavier draft, and tractors are often used for fall and spring plowing. Ground limestone is used to some extent, and stable manure is carefully saved and applied to the stubble land and grass land before plowing. Commercial fertilizers are not used.

Thorough drainage of this soil is necessary, and tiling of all fields is recommended. A larger acreage should be devoted to legumes, and corn should not be grown more than two years in succession on the same land. Green-manure crops turned under would also improve the physical condition of this soil.

#### CLINTON SILT LOAM

The surface soil of Clinton silt loam in wooded areas is light-brown or light grayish-brown fine-textured silt loam, 2 or 3 inches thick, which contains some grass roots and finely divided leaf mold. This layer is underlain, to a depth ranging from 8 to 12 inches, by light grayish-yellow or pale grayish-yellow floury silt loam. The upper subsoil layer is finely granular pale-yellowish or dull yellowish-brown friable heavy silt loam or silty clay loam. The granules are distinctly subangular, and many of them are covered with a grayish film. Below a depth ranging from 20 to 24 inches is the lower subsoil layer, which continues to a depth of 4 or 5 feet. This layer consists of pale yellowish-brown or brownish-yellow tough, compact, crumbly silty clay loam mottled with featherings of gray and some iron stains. The partly weathered parent material, which is light-gray, yellowish-brown, and rust-brown friable heavy silt loam streaked with black oxide of iron stains, underlies the subsoil. At the 7-foot depth the gray color predominates and the mass is even-textured structureless silt loam.

The foregoing description is representative of several profiles examined in soils in the northeastern corner of the county. Slight variations as to thickness and color of the surface soil and the degree of mottling near a depth of 3 feet naturally occur within mapped areas of this soil, but these variations are of little importance. In cultivated fields the surface soil, to a depth ranging from 8 to 12 inches, is light yellowish-gray mellow silt loam that has a pale ash-gray appearance and a floury feel when dry. After rains the surface soil is much darker, and the soil closely resembles the lighter colored areas of Tama silt loam. Along the Marion County line, just south of the Des Moines River bottoms, a few areas approach closely to very fine sandy loam, but on account of their small extent and variable texture they were not separated.

The most extensive areas of Clinton silt loam are in the extreme northeastern corner of the county and south of Indianola in Otter and White Oak Townships. Smaller isolated areas occur in all parts of the county. Most of the soil occupies the crests of ridges and narrow divides just back from the rough broken valley escarpments. The surface ranges from flat to gently rolling, and drainage is good. The subsoils are moderately retentive of moisture.

About 80 per cent of this soil is used for the production of staple crops and for pasture land. The wooded areas support a tree growth consisting mostly of elm, hickory, black oak, white oak, and aspen, and an undergrowth of hazel.

Corn is the principal crop and occupies the largest acreage. Wheat, oats, timothy and clover, barley, and rye are crops of less importance. All the grain and hay are used on the farms. Crop yields are lower than those obtained on Tama silt loam, except in a few places where a higher wheat production is reported.

Farmers consider this soil superior to the heavier prairie soils for the production of grasses, and a few excellent bluegrass pastures were

observed. The principal livestock industries are hog raising, raising and feeding of beef cattle, and, less extensively, dairying. Several small flocks of sheep are kept, principally for the production of wool, though a few lambs are sold yearly.

Well-improved Clinton silt loam is valued at prices ranging from \$125 to \$175 an acre, depending on location and the character of the improvements. Unimproved land has a much lower value.

This soil is prevailingly poor in organic matter, and improved cultural methods that will add to the present store should be employed. Green-manure crops, preferably legumes such as sweet clover and red clover, should be more extensively grown and turned under. Stable manure should also be more carefully saved and applied in the fall before plowing. In the rougher areas tillage operations should be so conducted as to reduce the damage done by erosion. As both surface soil and subsoil are acid, the use of ground limestone should prove of great value.

#### CARRINGTON SILT LOAM

The surface soil of Carrington silt loam, in the virgin state, consists of two distinct layers, a dark grayish-brown even-textured silt loam layer 2 or 3 inches thick, which contains an abundance of grass roots, and a dark grayish-brown or very dark grayish-brown mellow, friable granular silt loam layer which continues to a depth of 12 or 14 inches without change. The upper subsoil layer is dark-brown or dark yellowish-brown finely granular silt loam. It is underlain, at a depth of 18 or 20 inches, by yellowish-brown slightly friable silty clay loam or silty clay, in most places  $1\frac{1}{2}$  or 2 feet thick. Faint gray mottles occur with depth. The small soil aggregates are subangular, and many of them are covered with a dark-brown film, which gives the undisturbed mass a darker appearance than where the granules are broken up. Below a depth ranging from 40 to 60 inches is the parent material of yellowish-brown gritty silty clay conspicuously mottled with gray, rust brown, and red. In the upper part of the substratum the red predominates in many places, but below the 6-foot depth yellow mottles predominate. The structure ranges from coarsely granular to nut. Leaching has removed the carbonates to a great depth, and neither surface soil nor subsoil gives a reaction with acid. A study of virgin areas was difficult on account of their small extent. Cultivation, however, has altered only the surface layer, and the fields have a uniformly dark color when dry and appear black when wet.

Throughout the more rolling areas erosion has thinned the surface soil somewhat, and the color is slightly lighter, owing to the more active leaching of the carbonaceous matter. In some areas the soil near a depth of 3 feet is gritty silty clay mottled with gray, rust brown, and red. In the southern part of the county, especially in Otter, Whitebreast, and Belmont Townships, the presence of small quantities of yellow shale imparts to the lower subsoil layers more pronounced mottles and a slightly soapy feel.

Carrington silt loam occurs in all parts of the county. It occupies the lower part of the more gentle slopes and comparatively narrow bands bordering the strips of bottom along streams and drainage ways.

The surface of the land is gently sloping or undulating, and the slopes are free from gullies and furrows. Drainage is well established and is sufficient for crop needs.

Carrington silt loam is practically all in cultivation or in pasture. The only tree growth consists of windbreaks that have been set out to the north and west of farm dwellings. This is considered a valuable agricultural soil and is handled in practically the same manner as the adjoining Tama silt loam. Methods suggested for the improvement of Tama silt loam are also applicable to this soil. Corn, oats, and hay constitute the principal crops, and all the grain and hay is used locally. Yields are about the same as those obtained on Tama silt loam. Hog raising and the raising and feeding of beef cattle are the principal livestock industries. Dairying and the production of chickens and eggs, carried on as side lines, are also important and bring in considerable revenue.

#### CARRINGTON LOAM

Carrington loam has a dark grayish-brown or very dark grayish-brown mellow finely granular surface layer varying from 8 to 14 inches in thickness. This grades into the upper subsoil layer, which consists of yellowish-brown, friable, crumbly silty clay loam. Below a depth varying from 22 to 26 inches is the true subsoil of yellowish-brown sandy clay mottled with gray, reddish brown, and some oxide of iron stains. Small fragments of the parent till occur with depth, and here and there a small boulder is embedded in the soil. The soil is acid in reaction throughout. Although this soil is very uniform in color and texture slight variations occur, owing largely to differences in topographic position. Along the upper part of the slopes the content of silt is high, whereas near the bottom the proportion of grit and sand increases. Included with mapped areas of this soil are a few areas of Carrington silt loam and Shelby loam too small to separate on the scale used in the soil map.

Carrington loam is not extensive in Warren County. Small isolated areas are scattered throughout all parts of the county. The larger, more continuous areas occur along Middle Creek north of Norwalk, in the southeast quarter adjacent to Wolf Creek, and bordering the bottoms of Squaw Creek west of Medora. This soil, like Carrington silt loam, occupies the more gentle stream slopes. It differs from Carrington silt loam in its slightly more pronounced relief. Throughout the more rolling areas repeated cultivation has allowed erosion to furrow the surface with shallow gullies.

Drainage is generally good and the soil as a whole is retentive of moisture. Owing to its openness and mellowness it warms up a little earlier than the adjoining silt loam and can thus be cultivated under a wider range of moisture conditions.

Carrington loam is cultivated largely in conjunction with the adjoining Tama silt loam, and the same methods of farming are employed. Corn, oats, wheat, and hay are the chief crops. Barley, rye, rape, and sorghum are grown to a small extent, and gardens are maintained on most farms. Crop yields are practically the same as on the adjoining Carrington silt loam and Tama silt loam.

Carrington loam responds readily to cultivation, and where systematic crop rotations, in which legumes play an important part, are followed, the fertility may easily be maintained. Barnyard manure, when available, is applied, and a few farmers have used ground limestone to advantage. Commercial fertilizer is not used.



Land of this kind is always sold with the adjoining Tama silt loam. The value is slightly less than of that soil.

#### CARRINGTON FINE SAND

The surface soil of Carrington fine sand is medium dark grayish-brown or very dark grayish-brown fine sand or loamy fine sand which contains a large percentage of organic matter. This layer is 6 or 8 inches thick and grades into the subsoil layer which consists of yellowish-brown or yellowish loose-textured fine sand that continues to a depth of 4 or 5 feet without appreciable change.

Where this soil occurs in close association with Tama silt loam and Shelby loam the color is predominantly darker, but in sections 8 and 35, T. 77 N., R. 22 W., the surface has much the same color as the adjoining Clinton silt loam and Lindley silt loam. Along the Lucas County line in section 36 of Whitebreast Township, the typical soil consists of dark-brown loose-textured loamy fine sand underlain at a depth of 10 or 12 inches by yellowish-brown sticky fine sand which in turn grades, at a depth of 20 or 22 inches, into a fine sand and gravel layer.

Carrington fine sand, which is of small extent, occurs in close association with the Tama silt loam and Clinton silt loam of the uplands. The two most extensive areas are 2 miles northeast of Summerset along the south side of Middle River and south of Norwalk on the south side of North River. Smaller isolated areas occur in Richland and Whitebreast Townships.

The surface of this soil is rolling or broken, and erosion has gullied many of the slopes. Drainage is excessive, and the soil is droughty.

Carrington fine sand is considered a good soil for the production of melons and truck crops, and the greater part of it is used for this purpose. The surplus melons are either peddled in the near-by towns or hauled to Des Moines, but the vegetables are all used on the farms. Corn occupies a small acreage, and some clover is grown. However, owing to the droughtiness of the soil, yields are low except in wet years. Native pastures are of little value, as the grasses make an indifferent growth. The virgin areas support a scant growth of native grasses, with some oak and jack pine trees.

This soil is farmed in practically the same manner as the adjoining Tama silt loam. On account of the open porous structure it warms up before the heavier soils and may be cultivated earlier. Crop rotations are seldom followed, except in the vicinity of Norwalk. Here melons are alternated with red clover, the clover serving as a green-manure crop. Stable manure is used to some extent as a fertilizer for melons.

#### SHELBY LOAM

The surface soil of Shelby loam is dark grayish-brown or very dark grayish-brown fine-textured loam, 1 or 2 inches thick. This layer is underlain, to a depth varying from 5 to 7 inches, by a slightly darker colored, finely granular layer. The upper subsoil layer, which in most places underlies the layer above rather abruptly, consists of yellowish-brown silty clay loam or gritty silty clay mottled with gray, rust brown, and a few iron stains. The three layers are predominantly acid, as leaching has removed the carbonates from them. Below a depth of 20 or 24 inches and continuing in most places to a

depth of  $3\frac{1}{2}$  or 4 feet is a fourth layer, consisting of yellowish-brown sandy clay mottled with rust brown, gray, and some red. Partly disintegrated rock fragments, many of them containing carbonates, also occur in various quantities. As in the layers above, this mass breaks down to small aggregates measuring one-fourth or one-eighth inch in diameter, forming what is commonly called a nut structure. The fifth layer occurs at a depth of 4 or 5 feet and consists predominantly of gray clay streaked and mottled with rust brown, yellow, and red. In cultivated areas plowing has thoroughly mixed the materials of the surface to a depth of 4 or 6 inches, and the fields have a dark-brown or brown color when dry and are very dark brown or black when wet.

Shelby loam, as mapped in Warren County, is predominantly loam though many minor variations in texture occur on account of the topographic position. Along the upper slopes, where the soil occurs below Grundy silt loam and Tama silt loam, the wash from these soils has increased the content of silt to such an extent that narrow bandlike areas might have been separated as silt loam. Midway the slopes, where erosion is most active, the surface in many places is sandy clay loam, whereas near the bottom of the slopes the texture approaches fine sandy loam in many places. Throughout the southern half of the county beds of sandy shale, which usually occur just below the glacial material, come within the 3-foot depth in many places. In such localities the lower subsoil layer is predominantly mottled with bright yellow and has a slightly soapy feel.

Shelby loam is the most extensive soil in Warren County. The largest areas are in the southern half of the county, and smaller areas occur in all parts of the northern townships. The soil occurs as ribbonlike strips bordering most of the rivers and creeks. The surface is rough or broken, and where the original covering has been removed it is badly gullied and eroded. Drainage is excessive.

Approximately 33 per cent of this land has been cleared, and the remainder is left in its natural condition and is used for pasturing beef cattle, dairy cows, work animals, and sheep. The virgin areas support a rather scanty growth of bluegrass, oak, and elm.

The cultivated areas generally include the more gentle slopes. This soil is always farmed in conjunction with the adjoining Grundy silt loam and Tama silt loam and the same staple crops, corn, oats, and hay, are produced. Yields, however, are lower, corn yielding from 30 to 35 bushels to the acre, oats from 20 to 30 bushels, and hay from 1 to  $1\frac{1}{2}$  tons. Sweet clover grows wild along ditches and road cuts and is successfully produced as a forage crop on some farms. Alfalfa occupies a small acreage. The seed should be inoculated for best results, and liming is necessary to give the plants sufficient start to allow the roots to reach the store of carbonates in the lower subsoil layer. Manure is not applied so extensively as on the adjoining prairie soils.

Erosion<sup>4</sup> is the most serious problem on this soil, and the steeper slopes should never be left bare. Bluegrass should be more extensively grown. If the slopes were seeded to this grass, it would not only protect them but would greatly increase their value as pasture land. Alfalfa and sweet clover could also be profitably grown on the

<sup>4</sup>DULEY, F. L., and MILLER, M. F. EROSION AND SURFACE RUN-OFF UNDER DIFFERENT SOIL CONDITIONS. Missouri Agr. Expt. Sta. Research Bul. 63, 50 p., illus. 1923.

more gentle slopes. Where the slopes have been gullied, brush and concrete dams would aid in their reclamation.

Land of this kind is always sold with Tama silt loam and Grundy silt loam. It is not considered nearly so valuable as either of the other soils mentioned.

#### SHELBY SILT LOAM

The surface soil of Shelby silt loam consists of dark grayish-brown mellow finely granular silt loam, from 5 to 7 inches thick. The subsoil is yellowish-brown gritty sandy clay loam which is underlain, at a depth of 24 or 26 inches, by yellowish-brown or light-brown gritty clay mottled with yellowish brown, gray, and red. Fragments of the parent till, including lime-bearing materials, occur in streaks near a depth of 3 feet. The weathered layers have a distinct nut or coarsely granular structure.

This soil differs from Shelby loam in surface characteristics only, owing no doubt to topographic position. It occurs typically around the heads of drainage ways, and the slopes are less steep and are somewhat shorter than in the loam. This feature has allowed the accumulation of greater quantities of silt. Like Shelby loam it is an erosional soil and necessarily includes a number of textural variations. Included with mapped areas of this soil are a few areas of Carrington silt loam and Carrington loam of such small extent that separation is impossible.

The surface is less rolling than that of Shelby loam, and gullies and water furrows are not so common. Surface drainage is inclined to be excessive, but the subsoils are retentive of moisture, and crops seldom suffer from drought.

Shelby silt loam occurs only in the southeastern and northwestern parts of the county. The most extensive areas are along the south side of Middle River north of St. Marys. The areas are comparatively small and isolated.

Approximately 50 per cent of this soil is under cultivation and the remainder is left in its natural condition and used for pasture. Corn, oats, and hay are the principal crops. Yields are somewhat lower than those obtained on the adjoining Grundy silt loam and Tama silt loam. Farm practices, however, are the same. A few hogs and cattle are pastured.

Shelby silt loam should be devoted more extensively to pasture. Bluegrass makes an excellent growth and a much larger acreage should be planted to this crop. Gullied areas may be reclaimed by building brush and concrete dams.

#### LINDLEY SILT LOAM

The surface soil of Lindley silt loam, to a depth of 1 or 2 inches, consists of brown or grayish-brown silt loam which contains a large quantity of humus. This is underlain by a light brownish-gray or pale yellowish-gray floury silt loam layer, 3 or 4 inches thick in most places. This layer is underlain rather abruptly by the true subsoil. The upper part of the subsoil is pale yellowish-brown silt loam with a crumbly or coarsely granular structure, and the lower part, below a depth of 16 or 18 inches, is bright-yellow or yellowish-brown compact friable silty clay or fine sandy clay slightly mottled with faint

featherings of gray. Compactness increases with depth, and when dry chunks of the lower subsoil layer are broken up the mass has a distinct subangular appearance, the aggregates measuring one-fourth inch or more in diameter. The number of fragments of the parent till increases with depth. Many of these rock fragments contain carbonates and the soil near a depth of 3 feet is distinctly calcareous in many places. In some areas midway of some of the steeper slopes nearly all the surface covering has been washed away, whereas near the bottom of the slopes the soil is somewhat deeper, owing to colluvial wash. Included with mapped areas of this soil are a few patches that might have been separated as Lindley loam, Shelby loam, or Shelby silt loam had they been sufficiently large and of enough agricultural importance.

Lindley silt loam occurs in only a few widely scattered isolated areas. The more extensive areas occur in the northeastern corner of the county as narrow, ribbonlike bands bordering the bottoms of Des Moines and Middle Rivers. This soil everywhere occurs in association with Clinton silt loam, and its light color is doubtless caused by the wash from the Clinton soil. The surface is rough or broken, and the slopes are badly gullied. Practically none of the land is fit for cultivation. Drainage is excessive, though the subsoils are retentive of moisture.

This soil is not considered valuable for agriculture. It is all left in its natural condition and is used for pasture. The forest growth consists mainly of elm, oak, hickory, aspen, and maple. Most of the trees are small and scattered. Bluegrass makes an excellent growth, and the more gentle slopes should receive additional seedings to improve the stand. This would prevent sheet erosion and increase the value of the soil for pasture. Lindley silt loam should not be cultivated.

#### WAUKESHA SILT LOAM

The surface soil of Waukesha silt loam is dark grayish-brown or very dark grayish-brown mellow somewhat friable silt loam 16 or 18 inches thick. When dry the color is dark brown and when wet the fields have a distinct black color. This layer grades into a subsoil of yellowish-brown silty clay loam faintly mottled with gray, which continues to a depth of 4 or more feet without change. The structure is finely granular in the upper part of the subsoil, the soil aggregates becoming somewhat larger with depth. Throughout the bottoms of Des Moines River the subsoils are duller in color than typical. They become more friable with depth, in many places grading into yellowish-brown loamy fine sand at a depth of 3 or 4 feet. Otherwise the soil is uniform, except for slight variations in the color and thickness of the surface layer.

Waukesha silt loam occupies the second and third terraces of Des Moines, North, Middle, and South Rivers and some of the larger creeks, lying slightly higher than the associated Bremer silt loam. The larger areas occur near Wick, Lida, and southeast of Clarkson. The soil lies above the reach of ordinary overflow and has an elevation of 10 or 12 feet above the normal level of the rivers and 6 or 8 feet above that of the creeks. At Wick it occupies a third terrace position, about 20 or 25 feet above the second terraces. The surface, except at Wick where it is somewhat rolling, is level or gently sloping. Drainage is sufficient for crop requirements.

Practically all of this soil is used for the production of staple crops or for pasture. Corn is the principal crop and occupies the largest acreage. Yields range from 38 to 45 bushels to the acre, though on improved lands yields of 65 and 85 bushels are not uncommon. Wheat, oats, clover, and timothy are also important crops. All the corn, oats, and hay are used on the farms as feed for the work animals, hogs, and cattle, but wheat, the principal cash crop, is sold in outside markets. Farm practices are similar to those in use on Tama silt loam.

Waukesha silt loam is naturally a rich soil, and under proper management its fertility may be maintained and increased. Definite crop rotations including legumes should be followed. Green-manure crops should also be grown. Applications of ground limestone have proved beneficial, and it is recommended that the use of this material be extended. Limestone not only corrects the acidity but improves the physical condition of the soil. Deeper plowing and more thorough preparation of the seed bed are also necessary.

#### WAUKESHA LOAM

Waukesha loam has a surface soil of dark grayish-brown or very dark grayish-brown friable loam from 15 to 18 inches thick. Beneath this layer and continuing to a depth of 20 or 22 inches is the upper subsoil layer of finely granular brown or yellowish-brown loam. This layer is underlain by yellowish-brown fine sandy clay loam which continues to a depth of 38 inches, where it grades into a layer of yellowish loamy fine sand.

Waukesha loam occurs only on the terraces of Des Moines and North Rivers. Except for one area, just east of Carlisle, which includes about 40 acres, the soil occurs as small knolls scattered throughout areas of Bremer silt loam.

Areas of Waukesha loam have level or gently undulating surfaces. Drainage is well established and is adequate for crop needs during favorable seasons. Owing to the presence of a substratum of fine sand, the subsoils are not so retentive of moisture as those of Waukesha silt loam.

The greater part of this soil is under cultivation, and because of its friability it is easily tilled. It warms up earlier than the adjoining Bremer silt loam and therefore allows earlier planting and maturity of the crops. The staple crops, corn, oats, and hay, are grown and under favorable seasonal conditions yields are only slightly less than those obtained on Waukesha silt loam. During periods of drought, however, crops are likely to fire. Some barnyard manure is used, and during the year of the survey a small quantity of ground limestone was applied to the land.

The methods suggested for the improvement of Waukesha silt loam apply equally well to this soil.

#### BREMER SILT LOAM

The surface soil of Bremer silt loam consists of very dark brown or black mellow silt loam 16 or 18 inches thick. The upper part of the subsoil is dark-brown or dark grayish-brown heavy silt loam or silty clay loam faintly mottled with gray featherings. At a depth ranging from 24 to 28 inches this layer grades into dark grayish-brown silty clay loam or silty clay mottled with rust brown, bluish

gray, and yellowish brown. Mottles increase with depth, and iron concretions are numerous in many places. The soil is fairly uniform throughout the county. The surface soils naturally vary somewhat in texture and thickness, but not sufficiently to necessitate the separation into other soil types. Along the outer edges of the areas bordered by Shelby loam, the soil is more friable, owing to inwash of greater quantities of sand. Some included areas resemble loam and silty clay loam in texture. The subsoils vary only in the number of mottles in the lower parts.

Bremer silt loam occurs on the terraces of all the rivers and larger creeks of the county, principally in the vicinity of Carlisle, west of Summerset, and in the northern part of Allen Township. The surface is flat or very gently sloping toward the streams. Ordinarily the soil occupies a position about 2 or 3 feet above the first bottoms, but in many places the merging of the terraces and first bottoms was so gradual that boundaries were difficult to draw.

Owing to the compactness of the subsoil, drainage of this soil is only moderately well developed. This condition has been overcome, in a number of places, by the construction of open ditches and the installation of tiles.

Bremer silt loam, where well drained, is considered a valuable agricultural soil, and approximately 80 per cent of it is under cultivation. The remainder is left with its natural cover of grass and is used for pasture. A few areas are wooded with willow, oak, cottonwood, and elm.

Corn, oats, wheat, and hay are the principal crops, corn occupying the larger acreage. Oats and wheat do well, especially wheat. All the corn, oats, and hay are used on the farms as feed for the beef cattle, hogs, and work animals commonly kept, and the wheat is sold to outside markets. Corn yields from 38 to 45 bushels to the acre, though much larger yields are reported; oats from 35 to 55 bushels; wheat from 20 to 30 bushels; and hay  $1\frac{1}{2}$  or 2 tons.

The methods of managing this soil are similar to those in use on Grundy silt loam. No barnyard manure or commercial fertilizer is used.

Drainage is of great importance. All fields should be well tiled and ditched to allow freer movement of the drainage waters emptied at the back of the benches. Crop rotations in which legumes are used as green-manure crops would also improve the fertility and physical condition of the soil.

Land of this kind is usually sold with the adjoining Shelby loam, Tama silt loam, and Wabash silt loam, and the proportion of each soil included on a farm influences the selling price.

#### BREMER SILTY CLAY LOAM

Bremer silty clay loam consists of a dark-brown or almost black surface layer 10 or 12 inches thick, which is somewhat crumbly silty clay loam in texture. This is underlain to a depth of 3 or more feet by dark slate-colored or dark brownish-gray heavy compact silty clay which contains some iron stains and iron concretions. The organic-matter content of the surface layer is high, and when wet the fields are decidedly black.

This soil occurs only on the terraces of Des Moines, North, and South Rivers in a position slightly lower than that of the adjoining

Bremer silt loam and 1 or 2 feet higher than that of Wabash silt loam. The largest area is approximately  $2\frac{1}{2}$  miles northeast of Summerset. Three smaller areas occur in the vicinity of Carlisle. The surface is flat or very gently sloping. Natural drainage is poor, and tiling is necessary.

Bremer silty clay loam is of slight agricultural importance. However, it is all under cultivation and is farmed in conjunction with the adjoining Bremer silt loam. The soil is more difficult to handle and greater care must be taken to plow under proper moisture conditions. Yields are lower than on the silt loam.

Soil of this kind may be improved by the incorporation of greater quantities of humus. More thorough tiling is recommended, and it is necessary to place the laterals closer together than in the lighter textured soils. A small quantity of ground limestone was applied to this soil during the year of the survey, and as the soil is acid lime will no doubt prove beneficial.

#### BREMER LOAM

The surface soil of Bremer loam in Warren County is friable loam rich in organic matter. It is very dark brown when dry and black when wet. The organic-matter content disguises the texture in many places, and separation from the adjoining silt loam was difficult. The upper subsoil layer is grayish-brown silty clay loam, which at a depth ranging from 20 to 28 inches grades into yellowish-brown, gray, and rust-brown much heavier textured material. The surface soils of the higher areas are slightly lighter in color, and the lower subsoil layers are more strikingly mottled with yellow. Along the Polk County line in the extreme northeastern corner of Allen Township, some fine grit is present in the lower part of the subsoil. Both surface soil and subsoil are acid in reaction. Included with mapped areas of this soil are a few very small patches of Bremer silt loam and Bremer silty clay loam.

Bremer loam occurs in only four comparatively small areas east and northeast of Carlisle. All of the land is under cultivation. It is farmed in conjunction with Bremer silt loam and is managed similarly. Owing to its friability and mellowness, it warms up earlier than the silt loam and can be plowed under a wider range of moisture conditions. Crop yields are about the same as on Bremer silt loam.

The value of Bremer loam is practically the same as that of Bremer silt loam, with which it is commonly sold.

#### JUDSON LOAM

The surface soil of Judson loam consists of dark-brown or dark grayish-brown friable loam 16 or 18 inches thick. This is underlain, to a depth of 3 or more feet, by material which differs from that above in that the color becomes more yellowish with depth. The cultivated fields are black when wet. Leaching has entirely removed the carbonates.

Slight variations in color and texture occur in this soil. Included in mapping are a few inextensive areas of Judson fine sandy loam. These included areas are in sections 14 and 23, T. 76 N., R. 25 W. and in section 15, T. 77 N., R. 23 W. Combined with this soil also is one small area of Judson silt loam in sections 35 and 36, T. 77 N., R. 22 W.

This soil occurs as small isolated areas on the terraces of Middle River and Coal Creek. It lies slightly higher than the adjoining Waukesha silt loam and is 2 or 3 feet above the level of the first bottoms. The surface is flat or very gently sloping, but the land is subject to inundation. Owing to the porosity of the soil throughout, drainage is good.

Approximately all the Judson loam is under cultivation or is in pasture. A very small acreage supports a sparse growth of wild grasses and willows. Corn is the principal cultivated crop. Yields are lower than on the adjoining heavier soils. During dry seasons this soil is inclined to be droughty.

#### CALHOUN SILT LOAM

The surface soil of Calhoun silt loam is light-brown or light brownish-gray floury silt loam, 10 or 12 inches thick, which contains a small proportion of very fine sand. This layer rests on a gray distinctly floury layer, which in most places varies from 6 to 10 inches in thickness. The gray color is tinged with yellow and appears pale yellowish or yellowish gray. A third layer underlies the gray layer rather abruptly and continues to a depth of 30 or 33 inches with little change. It consists of grayish-yellow compact silty clay loam mottled with gray, rust brown, and yellowish brown. This layer is in turn underlain by a heavier textured and more intensely mottled layer.

Variations from the typical soil are common. In the area in section 9, T. 75 N., R. 23 W. the gray layer is less conspicuous, and faint iron stains are not uncommon. Here the color of the surface soil is also somewhat variable, owing to inwash from darker colored upland soils. Where this soil occurs in association with Carrington fine sand in section 22, T. 77 N., R. 23 W. the outer edges of the terrace are loamy.

Calhoun silt loam occupies the second terraces of North, Middle, and South Rivers and Whitebreast and Otter Creeks, where it occurs as small benchlike areas bordering the uplands. The surface is level or gently sloping. The soil occupies a position 3 or 4 feet above the first bottoms. Some areas seem sufficiently well drained for crop needs, though natural drainage is generally poor, owing to the imperviousness of the lower subsoil layer.

Practically all this soil is in cultivation to corn, oats, and clover. Winter wheat is frequently substituted for oats in the general rotation. The soil is managed in much the same way as the upland soils, Grundy silt loam and Tama silt loam, but yields are lower. The hay and all the grain, except wheat, are used on the farms.

Many farmers scatter barnyard manure over the fields in the fall before plowing. Limestone and commercial fertilizers are not applied.

Calhoun silt loam, like Jackson silt loam, is deficient in humus, and its fertility may be increased by following the cultural methods recommended for that soil. Tiling is also necessary, and the application of ground limestone would tend to improve the physical condition of this soil.



## JACKSON SILT LOAM

The surface soil of Jackson silt loam in Warren County consists of a layer, varying from 8 to 12 inches in thickness, which is prevailingly gray or brownish-gray friable silt loam. This layer is underlain by brown or yellowish-brown friable silt loam or loam which also varies from 8 to 12 inches in thickness. At a depth ranging from 20 to 24 inches the second layer grades into pale-yellowish heavy silt loam or friable clay loam which continues to a depth of 3 or 4 feet with little change other than an increased number of brown mottles and a few iron stains. Neither surface soil nor subsoil shows any trace of lime. Many very small areas of loam and fine sandy loam too intricately mixed to separate have been included in mapped areas of Jackson silt loam.

Jackson silt loam has a total area of 192 acres. It occurs only as small isolated patches on the terraces of Des Moines and South Rivers. It is  $1\frac{1}{2}$  or 2 feet above the first bottoms and 12 or 15 feet above the normal level of the streams and is beyond the reach of ordinary overflow. The surface is level, slightly hillocky, or ridgy, and drainage is good.

Approximately 95 per cent of this soil is under cultivation, and the remainder is covered by wild grasses and a scrubby growth of willow. Corn is the principal crop, but some wheat and clover are grown. Crop yields are less than those obtained on Waukesha silt loam. Corn yields from 32 to 36 bushels to the acre, wheat 12 or 15 bushels, and hay 1 or  $1\frac{1}{2}$  tons.

This soil is managed in practically the same manner as Waukesha silt loam. It is deficient in humus, and crop yields may be increased by growing and turning under an increased acreage of green-manure crops, preferably legumes. Systematic rotations should also be followed. As the soil is acid, ground limestone could be profitably used.

## WABASH SILT LOAM

The surface soil of Wabash silt loam consists of dark grayish-brown or very dark grayish-brown, mellow, even-textured silt loam from 14 to 16 inches thick. The organic-matter content is generally high, and when wet the fields are intensely black. The subsoil is predominantly dark slate-colored or very dark grayish-brown silty clay loam or silty clay which grades, at a depth of 28 or 30 inches, into a layer distinctly mottled with iron stains, and containing variable quantities of iron concretions.

As is true in most first-bottom or overflow soils, numerous variations from the typical soil occur. South of Lacona along Mill Branch are a few areas that differ from typical in that the soil, to a depth of 2 or 3 inches, is light brown or grayish in color and the subsoil is not so heavy as typical. Similar small areas are mapped in section 26 of Richland Township. Along Clanton Creek half a mile southwest of Wick the soil to a depth of 12 or 15 inches is brown, mellow loam. This is underlain by dark-brown silty clay loam which grades abruptly, at a depth of 18 or 20 inches, into black silty clay. Where this soil occurs in association with the silty clay loam and silty clay members of the Wabash series the transition from one soil to

the other is gradual in many places, and the boundaries are somewhat arbitrarily drawn.

Wabash silt loam is the predominant first-bottom soil in the county. It is most extensive along North, South, and Middle Rivers where many areas range from one-fourth mile to  $1\frac{1}{2}$  miles in width. Along the creeks the bands are narrower, and few of the valley floors of the intermittent streams are more than 350 feet wide.

The surface of Wabash silt loam is predominantly level or gently sloping toward the streams. It lies 10 or 12 feet above the normal level of the rivers and 4 or 5 feet above the level of the creeks. Since the rivers and many of the larger creeks have been straightened and dredged general inundations are rare and the water backs up only in the low areas during flood periods. Along the smaller creeks overflows are more frequent, but the water remains on the land for a short time only. In few places is natural drainage sufficient, and tiling is necessary for best results.

Wabash silt loam is considered a strong, valuable soil where it is well drained. About 70 or 80 per cent of it is under cultivation or in pasture. The wooded areas support a tree growth which consists chiefly of cottonwood, elm, ash, oak, hickory, and some willow.

Corn is the principal crop and can be grown on the same ground without reduced yields for longer periods than on the upland soils. Average yields of between 40 and 45 bushels to the acre are obtained. The corn is all used on the farms for feed. Winter wheat is an important cash crop, and yields range from 18 to 28 bushels to the acre. Oats and hay, mainly clover and timothy, are also grown. Oats yield from 40 to 60 bushels and hay  $1\frac{1}{2}$  or 2 tons to the acre. The principal livestock industries are hog raising and the raising and feeding of cattle. Dairying is unimportant.

Wabash silt loam is managed in much the same way as Tama silt loam and Grundy silt loam of the uplands. Owing to its mellowness it may be easily plowed under proper moisture conditions, and an excellent seed bed may be maintained. Fields are seldom plowed when too wet or too dry, as the soil is likely to clod. Barnyard manure is used less extensively than on the adjoining uplands.

Land values of Wabash silt loam vary. Where well drained, improved, and conveniently situated it is held at prices ranging from \$100 to \$175 an acre.

Drainage is of first importance. Open ditches are sufficient in many places, but tiling would no doubt give best results. Deeper plowing and definite crop rotations are also recommended.

#### WABASH SILTY CLAY LOAM

The surface soil of Wabash silty clay loam is dark grayish-brown or very dark grayish-brown silty clay loam varying from 12 to 16 inches in thickness. When dry the surface is very dark grayish brown and is crumbly. The subsoil is dark slate-colored or dark brownish-gray silty clay loam slightly mottled with rust brown. In some places the surface soil is almost black and is heavier textured than typical, whereas in other areas the surface layer is medium dark brown in color. This soil resembles Wabash silt loam in all characteristics, except the texture of the surface soil, and in many places boundaries between the two soils were difficult to determine. Both surface soil and subsoil have been leached of all carbonates.

Wabash silty clay loam occurs as rather large areas in the first bottoms of all the rivers and large creeks. The most extensive areas are in the northern half of the county along North River and Middle River. The soil occupies a position slightly lower than Wabash silt loam and is subject to overflow. Drainage is poor.

On account of its poor drainage and heavy texture the greater part of this soil, approximately 55 per cent, is left in its natural condition and is used for pasture. Ordinarily it supports a heavy growth of slough grass and a few areas are timbered with some oak, hickory, elm, cottonwood, and willow. The raising and feeding of cattle is probably the most important industry. The cultivated areas are devoted to corn, wheat, oats, and timothy. Corn occupies the largest acreage. Although this is naturally a strong, durable soil, yields are lower than on Wabash silt loam.

Areas of this soil may be reclaimed and improved by proper drainage. Tiles should be placed closer together than in the lighter textured soils and should be only slightly below plow depth. The growing of green-manure crops and the application of stable manure and ground limestone would also improve the physical condition of this soil.

#### WABASH SILTY CLAY

The surface soil of Wabash silty clay, to a depth varying from 10 to 14 inches, is very dark grayish-brown or almost black silty clay or clay rich in organic matter. When dry the mass is decidedly crumbly. The subsoil is grayish-brown or dark slate-colored silty clay or clay mottled with yellow iron stains. At a depth varying from 24 to 28 inches this layer is underlain by a predominantly heavier layer which is more intensely mottled with rust brown and iron stains. Iron concretions are also plentiful in the lower part of the subsoil. This soil is uniform in color and texture, except in a few included areas of Wabash silty clay loam and Wabash silt loam too small to separate on the map.

Wabash silty clay occurs on the bottoms of South River, Middle River, and Otter Creek. The more extensive areas are near Conger and in the bottoms of South River east of Hartford. Most of this soil lies along the outer edges of the bottoms. It extends out into the areas of silt loam in elongated fingerlike areas.

This soil occupies somewhat depressed or basinlike areas surrounded by Wabash silt loam. Since the streams have been ditched and straightened overflows are rare, but owing to the imperviousness of the surface soil and subsoil water stands on the surface for much longer periods than on the adjoining silt loam. Natural drainage is inadequate for crop needs.

A small acreage of Wabash silty clay is in cultivation. The greater part, however, is left in its natural condition and is used for pasture. The native cover consists of a rank growth of slough grass and a few scattered willow, elm, and oak trees.

Wabash silty clay, like Wabash silty clay loam, is a strong durable soil, but owing to its heavy texture and poor drainage it is difficult to cultivate. Corn occupies a small acreage, and some winter wheat is grown. A few head of cattle are pastured.

Better drainage and the incorporation of greater quantities of humus are necessary for the improvement of this soil. The use of ground limestone is also recommended.

#### WABASH LOAM

The surface soil of Wabash loam is dark grayish-brown mellow loam, 15 or 17 inches thick, which contains a high percentage of organic matter and silt. The subsoil is dark-brown loam that, at a depth of 22 or 24 inches, grades into brownish or dark grayish-brown friable clay loam faintly mottled with rust-brown splotches. Near a depth of 3 feet some particles of fine and coarse sand are present. Both the surface soil and subsoil are acid in reaction. Slight variations in the color and texture of the different layers also occur.

Wabash loam is inextensive. The largest area is  $2\frac{1}{2}$  miles southeast of Hartford in the bottoms of South River, and two small areas are just north of Carlisle along the Polk County line.

The surface is level, and the land lies at practically the same elevation as the adjoining Wabash silt loam. Drainage, except during periods of excessively high water, is usually sufficient for crop needs.

During the year of the survey (1925) approximately 80 per cent of the soil was under cultivation to corn. Yields of 40 or 45 bushels to the acre were obtained. In some years a small acreage of wheat and oats is grown with fair success. The wheat crop is more profitable than the oat crop. The wooded areas, which support a scant growth of willow, oak, elm, hickory, cottonwood, and locust, are used largely for pasturing the few head of cattle commonly kept.

Wabash loam is farmed in much the same way as the adjoining Wabash silt loam but is a little more easily cultivated and can be handled under slightly wider moisture conditions. Crop rotations are seldom followed, and corn is grown for several years before the ground is returned to small grain.

This soil is naturally strong and durable. However, overflows are a menace to successful crop production. If it were feasible to build levees to protect the land from inundation it could be profitably used for the production of all staple crops.

The value of this land, depending on the condition of improvements, is much the same as that of the adjoining Wabash silt loam.

#### GENESEE SILT LOAM

The surface soil of Genesee silt loam, to a depth varying from 10 to 14 inches, consists of grayish-yellow or light grayish-brown silt loam containing a high percentage of very fine sand. This layer grades into the subsoil, which has a predominantly pale-yellowish color and a silt loam or very fine sandy loam texture.

As is true in most overflow soils, a number of variations in the color and texture of the surface soils and subsoils occurs in Genesee silt loam. In section 26, T. 77 N., R. 22 W. the surface soil is gray friable silt loam, 10 or 12 inches thick, and the subsoil is composed of alternate layers of pale-yellowish silt and very fine sand. The area  $1\frac{1}{2}$  miles east of Ackworth has somewhat similar characteristics. Along Coal Creek, where this soil occurs in close association with Wabash silt loam, the surface soil in many places is darkened by the translocation of dark materials, and the boundaries were difficult to define.

Genesee silt loam is of alluvial origin and is derived from materials washed from the lighter colored uplands. The surface is level or very slightly hilly, and the areas occupy a position 8 or 10 feet above the normal level of the rivers and 4 or 5 feet above the creeks. The downward movement of the surface waters is rapid in most places. Nevertheless the water level in many areas is close enough to the surface to prevent thorough drainage.

Only a few areas of this soil have been mapped. Two are in the first bottoms of Des Moines River near Ford, two are along South River, and the largest continuous area lies along Coal Creek.

Cultivation of this soil is restricted to a few small patches that are farmed with the adjoining Wabash silt loam. Most of the land is left with its natural cover and is used for pasturing work animals. Corn and oats are grown to some extent, but yields are lower than on Wabash silt loam and are not so certain.

This soil is easy to manage and can be improved by the use of cultural methods suggested for Jackson silt loam and Calhoun silt loam.

#### SARPY SILT LOAM

The surface soil of Sarpy silt loam is light grayish-brown, yellow, or pale grayish-yellow mellow silt loam 8 or 10 inches thick. This layer is underlain by the pale-yellowish or brownish very fine sandy loam subsoil which, in turn, is underlain at a depth ranging from 30 to 33 inches by a stratum of fine sand or medium fine sand. At a depth ranging from 20 to 30 inches slight effervescence with acid was noticed, and the layer of fine sand was strongly calcareous. When wet the cultivated fields are much darker than when dry. In a few places the upper subsoil layer is somewhat darker than typical, ranging from light brown to brownish gray. The sand layer is reached at a variable depth.

This soil occurs exclusively on the first bottoms of Des Moines River where it occupies a position from 7 to 10 feet above the normal water level. It is subject to overflow, but water seldom remains on the land for long periods except during abnormal seasons. Drainage is usually sufficient for crop needs.

Approximately 50 per cent of the Sarpy silt loam remains with its original cover of wild grasses, willow, oak, and cottonwood and is used for pasture. Corn is the principal cultivated crop and occupies the largest acreage. Some oats, wheat, and clover are also grown. Cultural methods are similar to those in use on Wabash silt loam. Corn yields from 35 to 40 bushels to the acre, oats from 30 to 45 bushels, wheat from 15 to 22 bushels, and clover from 1 to 2 tons.

Sarpy silt loam is not considered so valuable as the better drained areas of Wabash silt loam. Its productiveness may be increased by the incorporation of more organic matter in the form of green-manure crops. The presence of lime in the lower subsoil layer should prove of great value in the production of such leguminous crops as alfalfa and sweet clover, provided overflows could be prevented.

#### SARPY VERY FINE SANDY LOAM

The surface soil of Sarpy very fine sandy loam is light yellowish-brown or light grayish-brown mellow very fine sandy loam, 16 or 18 inches thick. The upper subsoil layer is light brownish-yellow or

grayish-yellow very fine sandy loam which, at a depth ranging from 28 to 32 inches, is underlain by yellowish fine sand containing varying quantities of lime. Owing to its position, slight variations in color and texture are found. The transitions to Sarpy silt loam and Sarpy fine sandy loam are gradual, and in a few places the boundaries between these soils are more or less arbitrary.

Like Sarpy silt loam this soil occurs only in the bottoms of Des Moines River, where it occupies a slightly higher position than the silt loam. The surface is level. Occasional overflows injure growing crops or delay planting in the spring. Between overflows, however, drainage is inclined to be excessive, owing to the porosity of the entire soil.

During the year of the survey the greater part of this soil was cultivated to corn. Grain of good quality is produced, but yields are lower than on heavier bottom-land soils. A small acreage is sown to wheat and oats. In its native condition the land supports a rather scant growth of bluegrass and wild grasses and is used mainly for pasturing a few head of beef cattle and dairy cows. The tree growth on the few wooded areas consists chiefly of oak, elm, ash, cottonwood, and willow.

Sarpy very fine sandy loam warms up one or two weeks earlier in the spring than the heavier textured bottom-land soils and requires much lighter draft to cultivate. Very little manure is used.

This soil could be profitably used for the production of melons and all truck crops. If the land were disked, it would be well adapted to alfalfa and sweet clover.

The price of land of this kind varies considerably, depending on location, drainage, and improvements.

#### SARPY FINE SANDY LOAM

The surface soil of Sarpy fine sandy loam consists of light-brown or light grayish-brown fine sandy loam 10 or 12 inches thick. This layer is underlain by brown or yellowish-brown heavy fine sandy loam or very fine sandy loam which grades, at a depth of 28 or 30 inches, into a stratum of fine sand or very fine sand. Leaching has removed the carbonates from the surface soil, but there is sufficient lime concentration near a depth of 3 feet to cause strong effervescence.

In a few variations the substratum is darker colored and the underlying sand is free of carbonates. In section 14 of Richland Township an included area consists of grayish-brown fine sandy loam, 10 or 12 inches thick, underlain by dark-brown silt loam mottled with gray and some iron stains in the lower part. Such areas show no trace of lime.

Sarpy fine sandy loam occurs in the first bottoms of Des Moines River, mostly adjacent to the streams where the coarser materials have been deposited. Owing to the scouring effects of the overflow waters, the surface is uneven and consists of low ridges and depressions. This land lies higher than the adjoining Sarpy silt loam and Sarpy very fine sandy loam and is 12 or 14 feet above the normal water level. Except during overflows, subdrainage is excessive.

The greater part of this soil, approximately 85 per cent, is left in its natural condition and is used for pasture. It supports a scant growth of wild grasses and some elm, oak, and willow trees. Corn is grown on a small acreage, but average yields are low.

At present Sarpy fine sandy loam has little agricultural value. Truck crops of all kinds, particularly watermelons and cantaloupes, might be profitably grown. If the land were diked values would be increased, as crop yields would be more certain. Under such conditions alfalfa also could be grown to advantage.

#### SUMMARY

Warren County is in the south-central part of Iowa. It comprises an area of 570 square miles or 364,800 acres.

The county consists of a loess-covered drift plain. Along many of the streams erosion has exposed the underlying glacial drift. The relief ranges from level to undulating on the divides and from rolling to broken along the rivers and creeks. The elevation of the county above sea level ranges from 760 to 1,035 feet.

Warren County is drained by Des Moines River and tributary rivers and creeks. Most of the streams have cut valleys from 50 to 80 feet below the general level of the bordering uplands. Intermitent drainage ways ramify all parts of the county and afford ample drainage for most of the soils.

The population, as reported by the 1920 census, is 18,047, of which 79.9 per cent is classed as rural. The county was organized in January, 1849, and at present the entire population is made up of native-born Americans.

Transportation facilities in Warren County are good. Three great railroad systems, the Chicago, Rock Island & Pacific, Great Western, and Chicago, Burlington & Quincy, serve the county. The dirt-road system is complete. Rural mail routes and telephones serve all parts of the county, and schools and churches are conveniently located.

The climate is healthful. It is characterized by rather wide ranges in temperature. The mean annual rainfall is 32.97 inches. The average frost-free season is 166 days.

Agriculture is the principal industry, and according to the 1920 census 92.5 per cent of the total area is in farms. The value of the land is given as \$167.68 an acre. Corn, oats, wheat, clover, and timothy are the principal crops. Hog raising and the raising and feeding of beef cattle are important, and dairying and sheep raising are minor industries.

The soils of Warren County have been derived mainly from glacial and loessial material. However, it is believed that the soil-forming forces such as leaching, oxidation, and the accumulation of organic matter have contributed more to the present characteristics of the soils than differences in parent materials. The soils have been separated into 26 soil types representing 15 series.

The soils may be divided, according to their most striking characteristics, into dark-colored and light-colored groups. These two groups may be subdivided into well-drained and poorly drained soils on the basis of characteristics produced by different conditions of moisture.

On the upland the dark-colored soils which have developed under good surface and subsoil drainage conditions include the soils of the Tama, Carrington, and Shelby series. The Tama soils have developed over a silty material or loess on the smooth, gently rolling upland and are among the most valuable soils in the county. The Carrington soils have developed over glacial drift on gentle slopes

and compare favorably with the Tama soils. The Shelby soils are strongly rolling or rough and only a small part of their area is farmed. The Waukesha and Judson soils of the terraces also belong to this general group of dark-colored well-drained soils. These soils are highly productive. All of the soils of this group have dark-colored surface soils and yellowish-brown subsoils.

Dark-colored soils of another group have been subjected to excessive moisture during their development. The Grundy and Muscatine soils of the flat loess-covered upland, the Bremer soils of the terraces, and the Wabash soils of the first bottoms belong to this general group. These soils have very dark grayish-brown or black surface soils and gray or mottled subsoils. Almost the entire area of the Grundy and Muscatine soils is cultivated, and the land is regarded as the most valuable in the county. The value of the other soils depends on local conditions of drainage.

The light-colored soils of the county occupy areas that were formerly covered by forests. These soils have brown, gray, or grayish-brown surface soils and yellowish-brown subsoils. The Clinton and Lindley soils of the upland belong to this group. The former are developed over loess and the latter over glacial drift. The Jackson and Calhoun soils of the terraces and the Genesee and Sarpy soils of the first bottoms are also members of this group. The light-colored soils are not so productive as the dark-colored ones. The Clinton and Lindley soils are rolling or broken, and much of their area is good only for pasture. The Jackson and Calhoun soils have a smooth flat surface and are fairly productive. Their greatest deficiency is in organic matter. The Genesee and Sarpy soils are developed on newly laid river sediments and are variable in composition, drainage, and productiveness. Although these soils are durable, the crop yields are lower than on the more highly improved upland soils. The Genesee and Sarpy soils are all poor in organic matter and are not considered so valuable as the adjoining bottom-land and terrace soils.



[PUBLIC RESOLUTION—No. 9.]

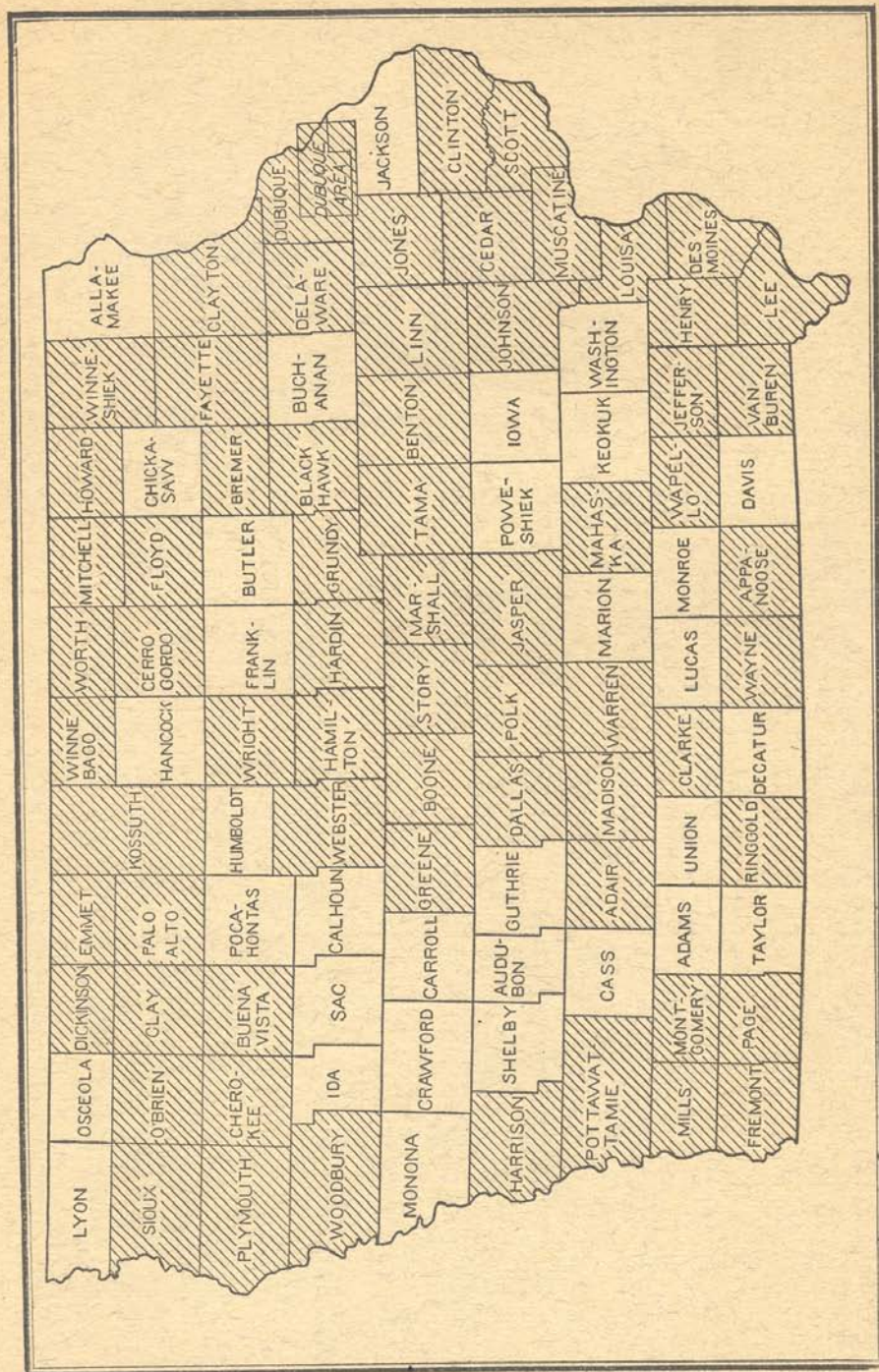
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

*Resolved by the Senate and House of Representatives of the United States of America in Congress assembled,* That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



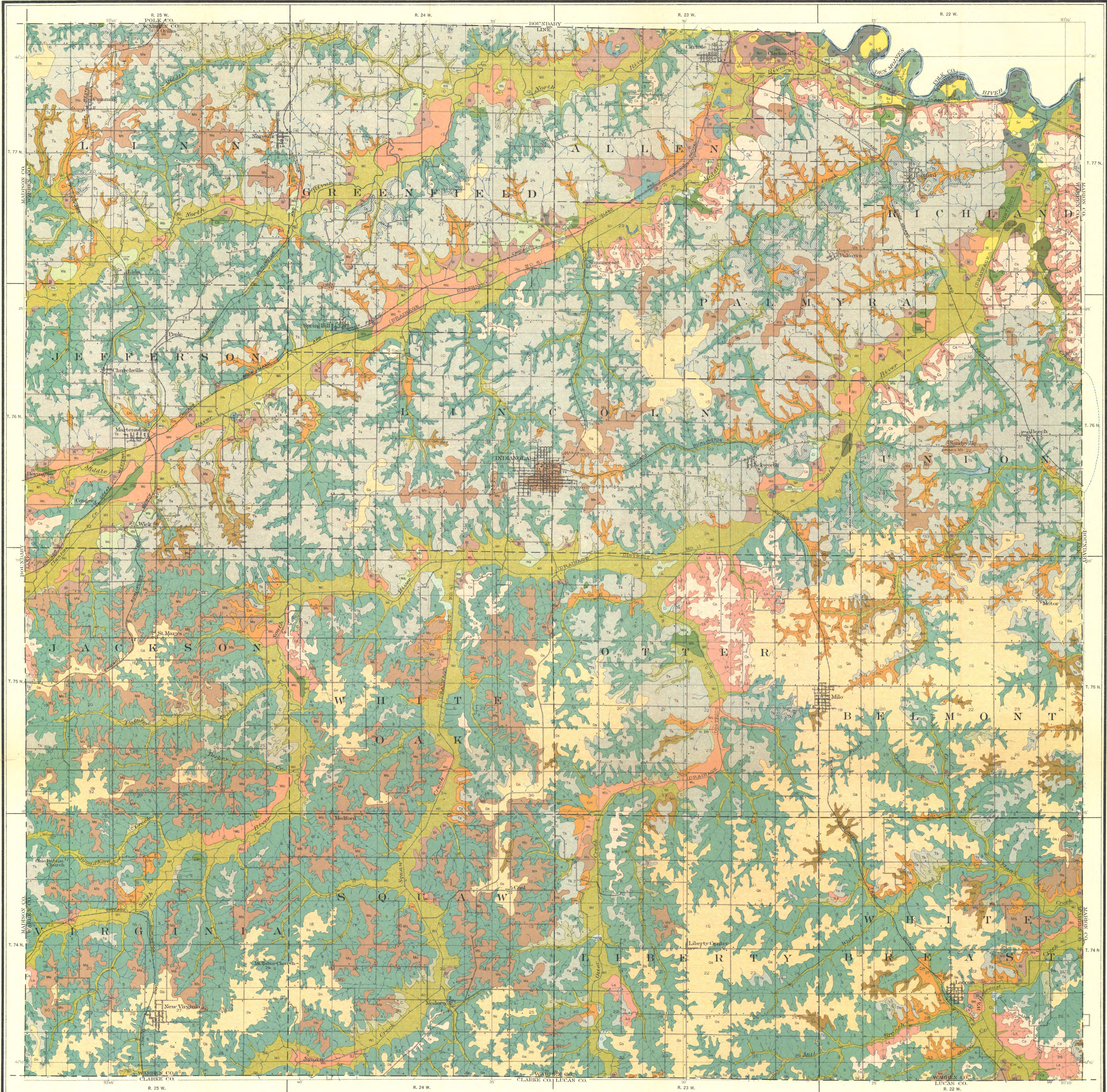
# NRCS Accessibility Statement

---

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at 1-800-457-3642 or by e-mail at [ServiceDesk-FTC@ftc.usda.gov](mailto:ServiceDesk-FTC@ftc.usda.gov). For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at <http://offices.sc.egov.usda.gov/locator/app>.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotope, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.





LEGEND

Bremner loam	Sarry fine sandy loam
Bremner silt loam	Sarry very fine sandy loam
Bremner silty clay loam	Sarry silty loam
Calhoun silt loam	Shelby loam
Carrington fine sand	Shelby silt loam
Carrington loam	Tama silt loam
Carrington silt loam	Shallow phase
Clinton silt loam	Wabash loam
Genesee silt loam	Wabash silt loam
Grundy silt loam	Wabash silty clay loam
Jackson silt loam	Wabash silty clay
Judson loam	Waukesha loam
Lindley silt loam	Waukesha silt loam
Muscataine silt loam	

CONVENTIONAL SIGNS

CULTURE  
(Printed in black)

City or Village, Roads, Buildings, Wharves, Jetties, Breakwaters, Levees, Lighthouse, Fort.	Railroads, Steam and Electric.
Secondary roads and Trails.	R.R. crossings, Tunnel.
Bridges, Ferry.	School or Church, Cemeteries.
Ford, Dam.	Bluff, Escarpment, Rock outcrop, and Triangulation station.
Mine or Quarry, Rock outcrop, Mined land.	Soil boundaries.
Stony and Gravelly areas.	U.S. township and section lines.
Boundary lines.	
Boundary lines.	
Boundary lines.	

RELIEF  
(Printed in brown or black)

Contours, Depression contours.	Mountain Peaks.
Sand, Wash, and Sand dunes.	Shore and Low-water line, Sandbar.

DRAINAGE  
(Printed in blue)

Streams.	Lake, Ponds, Intermittent lakes.
Intermittent streams.	Springs, Canals, and Ditches, Flumes.
Swamp, Salt marshes.	Submerged marsh, Tidal flats.